SHOUT
SHARE
IT

GRE
3108

HARVARD UNIVERSITY

❦

Library of the

Museum of

Comparative Zoology

The Great Basin Naturalist

VOLUME 38, 1978

EDITOR: STEPHEN L. WOOD

THE GREAT BASIN NATURALIST
BYU PROVO, UTAH
1939

PUBLISHED AT BRIGHAM YOUNG UNIVERSITY, BY
BRIGHAM YOUNG UNIVERSITY

1541
23

TABLE OF CONTENTS

Volume 38

Number 1 - March 31, 1978

Endangered and threatened plants of Utah: A reevaluation. Stanley L. Welsh 1
Plants of Navajo National Monument. J. D. Brotherson, G. Nebeker, M. Skougard, and J. Fairchild 19
Environmental interaction in summer algal communities of Utah Lake. Mark C. Whiting, Jack D. Brotherson, and Samuel R. Rushforth 31
Basidiomycetes that decay junipers in Arizona. II. R. L. Gilbertson and J. P. Lindsey . 42
Pinus longaeva in the Stansbury Mountains, Utah. P. A. Kay and C. G. Oviatt 49
Differential parasitism of *Peromyscus maniculatus* and *Peromyscus truei* by *Cuterebra* larvae. Jeffrey B. Llewellyn 51
An annotated list of the aquatic insects of southeastern Idaho, Part III. Ephemeroptera. Robert L. Newell and G. Wayne Minshall 55
Observations on the prey and nests of seven species of *Cerceris* (Hymenoptera: Sphecidae). Howard E. Evans and William L. Rubink 59
Vertebrate fauna of a radioactive leaching pond complex in southeastern Idaho. Douglas K. Halford and Jere B. Millard 64
New synonymy, new species, and taxonomic notes of North American *Pityophthorus* (Coleoptera: Scolytidae), Part III. Donald E. Bright 71
Fluctuation of a marsh habitat and the reproductive strategy of the Yellow-headed Blackbird. Roger J. Lederer 85
Hosts of juniper mistletoe at Walnut Canyon National Monument, Arizona. Frank G. Hawksworth and Robert L. Mathiasen 89
Allelopathic effects of Bur Buttercup tissue on germination and growth of various grasses and forbs in vitro and in soil. Bruce A. Buchanan, K. T. Harper, and Neil C. Frischknecht 90
New species of Nearctic *Neoperla* (Plecoptera: Perlidae), with notes on the genus. Bill P. Stark and Richard W. Baumann 97
Morphometry of sculpins (*Cottus*) in the Clearwater drainage, Idaho. O. Eugene Maughan 115
Correction: *Rhamnus cathartica* L. is not *Prunus nigra* Ait. from Alberta. R. Keith Shaw 123

Number 2 - June 30, 1978

Kaiparowits flora. Stanley L. Welsh, N. Duane Atwood, and Joseph Murdock 125
Range extension of *Onychomys torridus longicaudus* (Rodentia: Cricetidae) in northwestern Nevada. Mark D. Engstrom and Eugene D. Fleharty 180
The reproductive ecology of the Tahoe sucker, *Catostomus tahoensis*, in Pyramid Lake, Nevada. Joseph L. Kennedy and Paul A. Kucera 181
Primary productivity in meromictic Big Soda Lake, Nevada. R. P. Axler, R. M. Gersberg, and L. J. Paulson 187
Current status of cutthroat trout subspecies in the western Bonneville Basin. Terry J. Hickman and Donald A. Duff 193
Reproductive biology of the tui chub, Gila bicolor, in Pyramid Lake, Nevada. Paul A. Kucera 203

Distributional records for the Colorado flora. D. Wilken, W. Harmon, C. Feddema, and K. Harrington 208
A comparative analysis of the diatom flora on the snail Ampullaria cuprina from the Goshen Ponds, Utah. Larry L. St. Clair, Lorin E. Squires, and Samuel R. Rushforth 211
Growth of *Dipodomys ordii* (Rodentia: Heteromyidae). H. Duane Smith, Gary H. Richins, and Clive D. Jorgensen 215
Similarity between pronghorn and mule deer fecal pellets. Mark K. Johnson and James G. MacCracken 222

Number 3 - September 30, 1978

Utah flora: Fabaceae (Leguminosae). Stanley L. Welsh 225

Number 4 - December 31, 1978

Effect of irrigation on survival of third-stage *Haemonchus contortus* larvae (Nematoda: Trichostrongylidae). Graham R. Bullick and Ferron L. Andersen 369
Mountain ants of Nevada. George C. Wheeler and Jeanette Wheeler 379
New synonymy and new species of American bark beetles (Coleoptera: Scolytidae), Part VII. Stephen L. Wood 397
New range and new subspecies for the snake *Eridiphas sleveni*. John R. Ottley and Wilmer W. Tanner 406
A new subspecies of the snake *Lichanura trivirgata* from Cedros Island, Mexico. John R. Ottley 411
Vertical distribution of adult fish in Pyramid Lake, Nevada. Steven Vigg 417
An addition to the amphibian fauna of California. David A. Mullen and Robert C. Stebbins 429
Raptors of the Uinta National Forest, Utah. James A. Mosher, Clayton M. White, Joseph R. Murphy, and M. Alan Jenkins 438
Two new species of fleas of the genus *Meringis* (Siphonaptera: Hystrichopsyllidae). Richard B. Eads 447
The effects of radiation from uranium mill tailings on *Tradescantia*. E. A. Rechel and W. F. Campbell 456
Contributions to the biology of the woundfin, *Plagopterus argentissimus* (Pisces: Cyprinidae), an endangered species 463
An ecological and taxonomic investigation of *Peromyscus maniculatus serratus* in Idaho. Thomas L. Thurow 469
The eye fluke disease (Diplostomatosis) in fishes from Utah. Richard A. Heckmann and James R. Palmieri 473
Bite of wolf spider. Dorald M. Allred 478
Index to Volume 38 479

HE GREAT BASIN NATURALIST

lume 38 No. 1 March 31, 1978 Brigham Young University

MUS. COMP. ZOOL.
LIBRARY
JAN 18 1979
HARVARD
UNIVERSITY

GREAT BASIN NATURALIST MEMOIRS

Editor. Stephen L. Wood, Department of Zoology, Brigham Young University, Provo, Utah 84602.

Editorial Board. Kimball T. Harper, Botany; Wilmer W. Tanner, Life Science Museum; Stanley L. Welsh, Botany; Clayton M. White, Zoology.

Ex Officio Editorial Board Members. A. Lester Allen, Dean, College of Biological and Agricultural Sciences; Ernest L. Olson, Director, Brigham Young University Press, University Editor.

The *Great Basin Naturalist* was founded in 1939 by Vasco M. Tanner. It has been published from one to four times a year since then by Brigham Young University, Provo, Utah. In general, only previously unpublished manuscripts of less than 100 printed pages in length and pertaining to the biological natural history of western North America are accepted. The *Great Basin Naturalist Memoirs* was established in 1976 for scholarly works in biological natural history longer than can be accommodated in the parent publication. The *Memoirs* appears irregularly and bears no geographical restriction in subject matter. Manuscripts are subject to the approval of the editor.

Subscriptions. The annual subscription to the *Great Basin Naturalist* is $12 (outside the United States $13). The price for single numbers is $4 each. All back numbers are in print and are available for sale. All matters pertaining to the purchase of subscriptions and back numbers should be directed to Brigham Young University, Life Science Museum, Provo, Utah 84602. The *Great Basin Naturalist Memoirs* may be purchased from the same office at the rate indicated on the inside of the back cover of either journal.

Scholarly Exchanges. Libraries or other organizations interested in obtaining either journal through a continuing exchange of scholarly publications should contact the Brigham Young University Exchange Librarian, Harold B. Lee Library, Provo, Utah 84602.

Manuscripts. All manuscripts and other copy for either the *Great Basin Naturalist* or the *Great Basin Naturalist Memoirs* should be addressed to the editor as instructed on the back cover.

10-78 650 34146

ISSN 0017-3614

The Great Basin Naturalist
Published at Provo, Utah, by
Brigham Young University

ISSN 0017-3614

Volume 38 March 31, 1978 No. 1

ENDANGERED AND THREATENED PLANTS OF UTAH: A REEVALUATION

Stanley L. Welsh[1]

Abstract.— Endangered and threatened plants of Utah are reevaluated. The lists are brought up to date, and species now known to be common are recommended to be removed from the proposed lists. Additional species are proposed to be added, including the new species, *Astragalus montii* Welsh.

Passage of the Endangered Species Act of 1973 (Public Law 23-205) provided the legal basis for establishment of lists of endangered and threatened plant species. Such lists were prepared under the direction of the Smithsonian Institution, and were published in the Federal Register (40: 27824-27924. 1975; 41: 24524-24572. 1976). These lists are preliminary and were based on best information available at the time. Much information has been developed since those lists were published, and since the work by Welsh, Atwood, and Reveal (1975) was completed in summary form.

This paper is written in an attempt to evaluate the status of rare plants in Utah based on current best information. Several plant species were placed on initial listings which are known to be commonplace. Others were omitted by error, oversight, or lack of information. Taxa have been described as new which were unknown at the time lists were first compiled. All of these factors must be considered, and the lists should be maintained to be as current as possible.

Constraints placed on federal land management agencies provide justification for continued work on the status of rare plants judged to be categorized as either endangered or threatened. All such agencies must consider the presence of such plant species before any land use planning can be accomplished. This constraint applies to all developments which take place on federally controlled lands.

Information on the nature of endangered and threatened plants in Utah must be explored on a continuous basis, since stability of plant populations is an ideal only; they fluctuate with the many variables of climate, biotic, edaphic, and human developmental factors. The philosophy of humanity wishing to preserve plant species of unknown value has been questioned by many people. Examples of construction projects being halted when endangered plant or animal species have been found serve to fuel a controversy in our utilitarian society. Idealistically, industrial and other kinds of development should be able to proceed without regard to any living species—whether plant or animal. Since that is not possible in many instances, then which should give way? A "three worms" argument can be brought to focus. Human enterprise should not be halted, or even seriously modified because of the presence on the site of anything as insignificant as "three worms." Therein lies the problem. Our basic ignorance of the nature and role of rare organisms in the ecosystem, and their place in the lives of mankind, should cause us to allow sufficient time to explore the possibilities.

---

[1] Department of Botany and Range Science, and Life Science Museum, Brigham Young University, Provo, Utah 84602.

The fact that extinction is a reasonable practice in nature is pointed to by knowledgeable people as an excuse for the reduction of those species encountered in the course of human expansion onto the natural plant communities of the earth. That plant life has been retreating because of utilization of lands for agriculture, cities and towns, industrial sites, thoroughfares, and other ancillary features of our culture is hardly in doubt. That certain plant species have been pushed to the point of extinction is apparent, but the question remains as to whether extinction by natural processes and that accelerated by our actions represent two kinds of events. Only the end results are the same. Natural extinction represents the removal, in a selective manner, of organisms which, commonly because of conditions of the environment, could not continue to reproduce in sufficient numbers as to maintain a viable population. Forced extinction involves wholesale removal or modification of indigenous plant communities, resulting in the death of populations. This latter type of extinction can involve both inadvertant and purposeful exploitation and has been justified on the basis of necessity—the greatest good for the largest number of human inhabitants. Exploitation without understanding of natural processes has led to catastrophes affecting both human and biotic populations.

Now, we are at a point in civilization where an awareness has developed that living things represent a finite resource which cannot be pressed endlessly into a shrinking environment without loss of substantial numbers of species. Lands considered as good for little except limited grazing in the first century of our occupation of Utah are now important as industrial sites and for resource exploitation, recreation, and other uses.

Prior to the establishment of the Endangered Species Act, expansion onto wild lands took place without regard to rare or unusual plants. It was easy to work without restrictive regulations, regardless of the consequences to plant populations. The cost of such a mode of operation was presumed to be advantageous in our competitive society, but was potentially high in cost of a basic natural resource—our rare plant species. They became endangered from human expansion for two reasons: ignorance of their existence and of their importance.

Given the opportunity of passing the costs of expansion on to future generations, or of bearing those costs at the present time, the present generation will likely defer the costs to the latter. Cost is not in monies alone, but involves all of our resources, including rare plants of unknown value. The Endangered Species Act provides an advocate for present and future generations, allowing all a chance to make determinations and to enable examination of rarities provided in our natural system. The costs of protection will be borne by all generations. Guaranteed is the possibility for pursuit of knowledge about rare plants, now and in the future. All of our indigenous plant species are a part of our heritage. We have driven some vegetative types and species to the edge of extinction. The loss of a few square kilometers of some widespread species can be tolerated because of the large extent of that type. However, the loss of a few square meters of a rare plant population can result in extinction. The Endangered Species Act stands to prevent extinction.

The lands have become increasingly valuable, and the indigenous plants will retreat to still smaller areas as demands are made for greater utilization of Utah lands.

Rarity of plant species is a concept which requires study. Utah is a large state with a great many habitat types in a vast elevational range. Botanical exploration of its lands was begun seriously only a century ago, and students of its flora have been relatively few. Only about a half dozen botanists have ever collected more than 5,000 numbers each from the confines of the state. Catalogues of the flora have always been incomplete because of the poorly known nature of the plant species. Numerous taxa have been described since 1950, and likely many more remain to be discovered. When a plant species is first recognized, its total range is likely known from a small to a very small area. Because of the small size of the known range, the plant is judged to be rare. Further exploration frequently demonstrates that the total range is larger than initially indicated. However, there are those species which occupy narrow ranges, usually on peculiar substrates, which are actually rare.

At the present, the knowledge of Utah plant species is only moderately developed. The distribution of common plants is fairly well documented, but the rare and purportedly rare plants require much additional work. The following summary lists represent the current information available on both proposed and candidate endangered and threatened species of plants in Utah.

ENDANGERED PLANT LISTS AND PROPOSED MODIFICATIONS

The current list of proposed endangered plants is presented in Table 1. Some 68 species, including 4 which are possibly extinct, are included. Evaluation of previous data and of that taken from recent collections indicates that the list should be modified. It is therefore proposed that some 12 species be downgraded to the status of threatened and

TABLE 1. Current list of endangered plants as cited in Federal Register publications (1975, 1976), their locality by county in Utah, and recommendations of status based on present data.

Endangered Plants	Locality	Recommendations
Allium passeyi Holmgr. & Holmgr.	Box Elder	no change
Arctomecon humilis Coville	Washington	no change
Astragalus cronquistii Barneby	San Juan	no change
Astragalus desereticus Barneby	Sanpete (PoEx)	no change
Astragalus detritalis M.E. Jones	Duchesne, Uintah	downgrade to T
Astragalus hamiltonii C.L. Porter	Uintah	downgrade to T
Astragalus harrisonii Barneby	Wayne	no change
Astragalus iselyi Welsh	Grand, San Juan	no change
Astragalus lentiginosus Dougl. var. *chartaceus* M.E. Jones	Sevier, Sanpete, Juab, Summit, Daggett	remove from list
var. *ursinus* A. Gray	Iron (?)	no change
Astragalus loanus Barneby	Garfield, Piute, Sevier, Wayne	remove from list
Astragalus lutosus M.E. Jones	Uintah	no change
Astragalus malacoides Barneby	Kane, Garfield	downgrade to T
Astragalus minthorniae (Rydb.) Jeps. var. *gracilior* (Barneby) Barneby		taxonomic synonym of Astragalus ensiformis M.E. Jones
Astragalus pardalinus (Rydb.) Barneby	Emery, Garfield, Wayne	remove from list
Astragalus perianus Barneby	Garfield, Piute	downgrade to T
Astragalus saurinus Barneby	Uintah	downgrade to T
Astragalus serpens Barneby	Garfield, Iron, Piute, Wayne	remove from list
Castilleja aquariensis N. Holmgr.	Garfield	no change
Castilleja revealii N. Holmgr.	Garfield	no change
Cryptantha breviflora (Osterh.) Payson	Daggett, Uintah Duchesne	remove from list
Cryptantha grahamii Johnst.	Uintah	downgrade to T
Cryptantha johnstonii Higgins	Emery	no change
Cryptantha jonesiana (Payson) Payson	Emery	downgrade to T
Cryptantha ochroleuca Higgins	Garfield	no change
Cuscuta warneri Yunker	Millard (PoEx)	no change
Cycladenia humilis Benth. var. *jonesii* (Eastw.) Welsh & Atwood	Grand, Emery	no change
Cymopterus minimus (Mathias) Mathias	Iron	no change
Echinocereus engelmannii (Parry) Lemaire var. *purpureus* L. Benson	Washington	no change

Table 1.– contd.

Endangered Plants	Locality	Recommendations
Erigeron flagellaris Gray var. *trilobatus* Cronq.	Iron	no change
Erigeron kachinensis Welsh & Moore	San Juan	no change
Erigeron maguirei Cronq.	Emery	no change
Erigeron religiosus Cronq.	Kane, Washington	no change
Erigeron zionis Cronq.	Washington	no change
Eriogonum ammophilum Reveal	Millard	no change
Eriogonum aretioides Barneby	Garfield	no change
Eriogonum corymbosum Benth. var. *davidesei* Reveal	Carbon	no change
var. *revealianum* (Welsh) Reveal	Piute, Garfield	downgrade to T
Eriogonum cronquistii Reveal	Garfield	no change
Eriogonum ephedroides Reveal	Uintah	downgrade to T
Eriogonum humivagans Reveal	San Juan	no change
Eriogonum hylophilum Reveal & Brotherson	Duchesne	no change
Eriogonum intermontanum Reveal	Grand, Emery, Uintah	no change
Eriogonum lancifolium Reveal & Brotherson	Carbon	no change
Eriogonum loganum A. Nels.	Cache	no change
Eriogonum smithii Reveal	Emery	no change
Eriogonum zionis J.T. Howell var. *zionis*	Kane, Washington	downgrade to T
Festuca dasyclada Hackel	Emery (?), Sanpete (PoEx)	no change
Gilia caespitosa A. Gray	Wayne	no change
Glaucocarpum suffrutescens (Rollins) Rollins	Uintah	no change
Hermidium alipes S. Wats. var. *pallidum* C.L. Porter	Duchesne, Uintah	remove from list
Heterotheca jonesii (Blake) Welsh & Atwood	Washington, no change Garfield	
Lepidium barnebyanum Reveal	Duchesne, Uintah	no change
Lygodesmia grandiflora (Nutt.) Torr. & Gray var. *stricta* Maguire	Carbon	check taxonomic status
Parthenium ligulatum (M.E. Jones) Barneby	Duchesne, Emery, Uintah	remove from list
Pediocactus sileri (Engelm.) L. Benson	Washington	no change
Penstemon concinnus Keck	Beaver, Millard	downgrade to T
Penstemon garrettii Pennell	Duchesne (?), Wasatch	no change
Penstemon grahamii Keck	Uintah	no change
Penstemon nanus Keck	Beaver, Millard	downgrade to T
Phacelia argillacea Atwood	Utah	no change
Phacelia indecora J.T. Howell	San Juan, Wayne	no change
Phacelia mammillariensis Atwood	Kane	no change
Physaria grahamii Morton	Carbon, Duchesne, Emery, Uintah	remove from list
Psoralea epipsila Barneby	Kane	no change
Ranunculus acriformis A. Gray var. *aestivalis* L. Benson	Garfield (PoEx)	no change
Sclerocactus glaucus (K. Schum) L. Benson	Duchesne, Uintah	no change
Sclerocactus wrightiae L. Benson	Emery, Wayne	no change
Townsendia aprica Welsh & Reveal	Sevier	no change
Viguiera soliceps Barneby	Kane	no change
Zigadenus vaginatus (Rydb.) Macbr.	Grand, Kane, San Juan	downgrade to T

some 8 be removed altogether from consideration as potentially endangered or threatened. Two additional species, now listed as threatened, should be upgraded to endangered. Those which should be downgraded include the following:

Downgraded Species

Astragalus detritalis.— This species is nowhere abundant in the Uinta Basin, but is broadly distributed, commonly on gravels from the vicinity of Duchesne east into Colorado.

Astragalus hamiltonii.— The Hamilton milkvetch occurs on the Wasatch Formation west of Vernal and alluvium over a relatively large area north to the vicinity of Tridel.

Astragalus malacoides.— This milkvetch is known from the vicinity of Fifty Mile Mountain on the Straight Cliffs plateau west to Four Mile Bench, and from the Circle Cliffs portion of Garfield County.

Astragalus saurinus.— Named from Dinosaur National Monument, where the plant is locally abundant on saline soils of several geological formations, *A. saurinus* is also known from as far south as Red Wash and from west of Vernal.

Cryptantha grahamii.— The Graham cryptantha is known from the environs of Willow and Hill creeks and from west of the Green River north of the junction of Willow Creek. The total range is somewhat more than 30 miles in length.

Cryptantha jonesiana.— This showy cryptantha is known from the Sinbad member of the Moenkopi Formation from near the San Rafael River south to the middle of the San Rafael Swell. The plants grow on shaly barrens, often in the pinyon-juniper or mixed desert shrub communities.

Eriogonum corymbosum var. **revealianum.**— This wild buckwheat has been shown to occur through the East Fork of the Sevier River and Otter Creek vicinities in both Piute and Garfield counties.

Eriogonum ephedroides.— The ephedra wild buckwheat is rare only in collections. It is known to occur in a rather broad area from western Colorado west to the Green River in Uintah County, Utah. The habitat is confined to Green River Shale. Plants occur in peculiar assemblages with *Artemisia pygmaea, Glaucocarpum suffrutescens, Cryptantha grahamii, Cryptantha barnebyi,* and many other unusual plants.

Eriogonum zionis var. **zionis.**— This pretty wild buckwheat is known from the White Cliffs escarpment in western Kane and eastern Washington counties. The total known range is more than 40 miles long, and consists of numerous disjunct populations.

Penstemon concinnus.— The range of this Great Basin endemic occurs in western Millard and Beaver counties. Although rarely collected, the plants are rather widely distributed in the Tunnel Springs, Mountain Home, and Needle ranges, and on the bahadas in both Pine and Hamblin Valleys.

Penstemon nanus.— The dwarf beardtongue occurs with *P. concinnus*, but extends east across the Pine Valley into the Wah Wah Mountains.

Zigadenus vaginatus.— The sheathed death camus occurs in disjunct populations, commonly in hanging gardens in San Juan and Grand counties. It is less frequent in those mesophytic assemblages than is *Primula specuicola* or *Mimulus eastwoodae.*

Delisted Species

Plants which should be removed (delisted) from the list of endangered species are as follows:

Astragalus lentiginosus var. **chartaceus.**— The papery speckled millkvetch remained obscure for more than half a century following its naming. Recent collections indicate the presence of a series of populations with compact inflorescences shorter than the leaves in the near vicinity of the type locality of this variety. They are connected to other populations which are uncommon but scattered through much of northern Utah.

Astragalus loanus.— The Loa milkvetch is another species whose identity long remained obscure. Collected first a century ago, the species was not named until the 1940s. The plants occur on volcanic gravels in Sevier, Piute, Wayne, and Garfield counties. Total extent of known range is almost 100 miles in length.

Astragalus pardalinus.— The panther milkvetch is a mirrored image species of both *A. pubentissimus* and *A. sabulonum.* Differences were observed by P. A. Rydberg, who described *A. pardalinus*, and were substantiated by R. C. Barneby, who placed it in *Astragalus.* The habitat occupied by this pretty plant is the sandy footslope of the San Rafael Swell and Henry Mountains in eastern Emery, Wayne, and Garfield counties. Recently, it has been found along the dip-slopes of the Curtis formation near the western margin of the San Rafael Swell. The total length of the area occupied is more than 100 miles long.

Astragalus serpens.— The plateau milkvetch is a handsome plant, long known from the type locality at Loa Pass in western Wayne County. It is a plant of the low sagebrush community on volcanic gravels. Recently it has been found in Piute, Garfield, and Iron counties. The populations, while disjunct, consist of few to very many individuals, which wax and wane with local conditions of weather. The area occupied is very large.

Cryptantha breviflora.— The Uinta Basin cryptantha occurs from the west central portion of the basin eastward through central Uintah County, and into the southeastern tip of Daggett County. It is one of the common species of the Uinta Basin.

Hermidium alipes var. pallidum.— Recent collections from the Uinta Basin indicate a broad range for the pale hermidium. It is at least common, and even locally abundant, in much of its range in lower elevation portions of Duchesne and Uintah counties.

Parthenium ligulatum.— This caespitose composite is known from the Green River Shale of both Duchesne and Uintah counties, and from the Carmel and Dakota formations in the San Rafael Swell in Emery County. It remains obscure, but hardly rare.

Physaria grahamii.— This plant has been one of the enigmatic species of the state. Collected by Graham in the 1930s, and named by C. V. Morton during that period, the entity was thought to be extinct when first listed in the Federal Register. It is now known rather widely from the escarpments of the Tavaputs, West Tavaputs, and other western plateaus in Carbon, Emery, Duchesne, and Uintah counties. Additionally, it occurs in west central Colorado.

Upgraded Species

There are two plant species which were cited as threatened on the Federal Register list of 1975, but which appear to have the limited range and potential for extinction of endangered plants. Therefore, it is proposed that they be upgraded to that status. Included in this category are the following (see Table 2):

Astragalus callithrix.— This obscure species is known from only a few localities throughout its range in Millard County, Utah, and Nye County, Nevada. The loss of any population might be sufficiently destructive that the species would be lost.

Cryptantha barnebyi.— The total area known to be occupied by this entity is apparently smaller than that in published maps of the distribution. The plant is a Green River Shale endemic and could be eradicated through exploitation of that material for its oil.

THREATENED PLANT LISTS AND PROPOSED MODIFICATIONS

Threatened plants as currently constituted are listed in Table 2. The present list consists of some 85 taxa but includes many taxa now recognized as being common. These were previously poorly known entities, which have been updated by contemporary collections. Because of the accumulated information, it is proposed that some 30 species be removed from the list of threatened Utah plants. Most of those proposed to be delisted have such broad ranges that they could be threatened only by the most widespread destruction of habitat, or by some specific and selective destructive force. Plants which should be delisted include:

Astragalus convallarius var. finitimus.— There are a series of populations of this plant extending through northern Washington County, western Iron County, and adjacent Nevada. This plant is not rare; its interpretation has been obscure.

Astragalus ensiformis.— When expanded to include the materials known as *A. min-*

Table 2. Current list of threatened plants cited in Federal Register publications (1975, 1976), their locality by county in Utah, and recommendations of status based on present data.

Threatened Plants	Locality	Recommendations
Arabis demissa Greene var. *lanugida* Rollins	Daggett	no change
var. *russeola* Rollins	Daggett, Uintah	no change
Asclepias cutleri Woodson	Grand, San Juan	no change
Asclepias ruthiae Maguire & Woodson	Emery, Grand, Wayne	no change
Astragalus ampullarius S. Wats.	Kane, Washington	no change
Astragalus barnebyi Welsh & Atwood	Garfield, Wayne	no change
Astragalus callithrix Barneby	Millard	up grade to E
Astragalus chloodes Barneby	Uintah	no change
Astragalus convallarius greene var. *finitimus* Barneby	Iron, Washington	remove from list
Astragalus cottamii Welsh	San Juan	no change
Astragalus duchesnensis M.E. Jones	Duchesne, Uintah	no change
Astragalus ensiformis M.E. Jones	Washington	remove from list
Astragalus lancearius A. Gray	Kane, Washington	no change
Astragalus oophorus S. Wats. var. *lonchocalyx* Barneby	Beaver, Iron	remove from list
Astragalus rafaelensis M. E. Jones	Emery	no change
Camissonia parryi (S. Wats.) Raven	Washington	remove from list
Castilleja parvula Rydb.	Beaver, Piute	no change
Castilleja scabrida Eastw.	Carbon, Duchesne, Emery, Garfield, Grand, Kane, San Juan, Sevier, Uintah, Wayne, Washington	remove from list
Corydalis caseana A. Gray	Salt Lake, Utah, Wasatch, Weber	remove from list
Cryptantha barnebyi Johnst.	Uintah	upgrade to E
Cryptantha compacta Higgins	Millard	no change
Cryptantha elata (Eastw.) Payson	Grand	no change
Cryptantha semiglabra Barneby	Washington	no change
Cryptantha stricta (Osterh.) Payson	Daggett, Summit, Uintah	no change
Cymopterus basalticus M.E. Jones	Millard	remove from list
Cymopterus coulteri (M.E. Jones) Mathias	Juab, Sevier, Utah	no change
Cymopterus duchesnensis M.E. Jones	Duchesne, Uintah	no change
Cymopterus newberryi (S. Wats.) M.E. Jones	Garfield, Grand, Kane, Millard, San Juan, Uintah, Washington, Wayne	remove from list
Cymopterus rosei M.E. Jones	Iron, Sanpete, Sevier, Washington	remove from list
Draba asprella Greene var. *zionensis* (C.L. Hitchc.) Welsh & Reveal	Washington	no change
Draba sobolifera Rydb.	Garfield, Piute	no change
Draba subalpina Goodman & Hitchc.	Garfield, Iron, Kane	no change
Epilobium nevadense Munz	Washington	no change
Erigeron abajoensis Cronq.	Garfield, Kane, San Juan	no change
Erigeron cronquistii Maguire	Cache	no change
Erigeron garrettii A. Nels.	Box Elder, Salt Lake, Utah	remove from list
Erigeron mancus Rydb.	Grand, San Juan	no change
Eriogonum clavellatum Small	San Juan	no change
Eriogonum eremicum Reveal	Millard	no change

Table 2.— contd.

Threatened Plants	Locality	Recommendations
Eriogonum jamesii Benth. var. *rupicola*	Kane, Washington	no change
Eriogonum nanum Reveal	Box Elder, Weber	no change
Eriogonum ostlundii M.E. Jones	Piute, Sevier	no change
Eriogonum panguicense (M.E. Jones) Reveal var. *alpestre* (Stokes) Reveal	Iron	no change
Eriogonum saurinum Reveal	Uintah	no change
Eriogonum thompsonae S. Wats.	Washington	no change
var. *albiflorum* Reveal		
var. *thompsonae*	Kane, Washington	no change
Eriogonum viridulum Reveal	Duchesne, Uintah	remove from list
Euphorbia nephradenia Barneby	Emery, Kane, Wayne	no change
Geranium marginale Rydb.	Garfield, Iron, Sevier, Wayne	remove from list
Gilia mcvickerae M.E. Jones	Garfield, Kane, Iron, Piute, Sevier, Uintah	remove from list
Haplopappus scopulorum (M.E. Jones) Blake	Iron, Kane, San Juan	remove from list
Hymenopappus filifolius Hook. var. *tomentosus* (Rydb.) Turner	Kane, Washington	no change
Lesquerella garrettii Payson	Salt Lake, Utah, Wasatch	no change
Lesquerella rubicundula Rollins	Garfield, Kane, Piute	no change
Lomatium minimum Mathias	Garfield, Iron, Kane	no change
Lupinus marianus Rydb.	Garfield, Piute, Sevier	remove from list
Machaeranthera grindelioides (Nutt.) Shinners var. *depressa* (Maguire) cronq. & Keck	Beaver, Millard	remove from list
Mertensia viridis A. Nels.		
var. *cana* (Rydb.) L.O. Williams	Summit	no change
var. *dilatata* (A. Nels.) L.O. Williams	Daggett	no change
Nama retrorsum J.T. Howell	Garfield, Grand, Kane	remove from list
Opuntia whipplei Engelm. & Bigel. var. *multigeniculata* L. Benson	Washington	remove from list
Parrya rydbergii Botsch.	Daggett, Duchesne, Summit, Uintah	no change
Penstemon abietinus Pennell	Iron, Sevier, Utah	remove from list
Penstemon acaulis L.O. Williams	Daggett	no change
Penstemon caespitosus Nutt. var. *suffruticosus* A. Gray	Beaver, Garfield, Piute	remove from list
Penstemon compactus (Keck) Crosswhite	Cache	no change
Penstemon leiophyllus Pennell	Garfield, Iron, Kane, Sevier, Washington	remove from list
Penstemon parvus Pennell	Garfield, Piute	no change
Penstemon uintahensis Pennell	Daggett, Duchesne, Uintah	no change
Penstemon wardii A. Gray	Sanpete, Sevier	no change
Peteria thompsonae A. Gray	Emery, Grand, Juab, Kane, San Juan, Washington	remove from list

Table 2.— contd.

Threatened Plants	Locality	Recommendations
Phacelia anelsonii Macbr.	Washington	no change
Phacelia cephalotes A. Gray	Kane, Washington	no change
Phacelia constancei Atwood	Emery, Garfield, Kane, San Juan	remove from list
Phacelia demissa A. Gray var. *heterotricha* J.T. Howell	Piute, Wayne Sevier	remove from list
Phacelia howelliana Atwood	Grand, San Juan	no change
Phacelia rafaelensis Atwood	Emery, Wayne, Washington	remove from list
Phacelia utahensis E.G. Voss	Sanpete, Sevier	no change
Phlox cluteana A. Nels.	San Juan	no change
Phlox gladiformis (M.E. Jones) E. Nels.	Garfield, Iron, Washington	no change
Phlox grahamii Wherry	Uintah	remove from list
Phlox jonesii Wherry	Washington	remove from list
Primula maguirei L.O. Williams	Cache	no change
Primula specuicola Rydb.	Grand, Kane, San Juan, Wayne	remove from list
Puccinellia parishii A.S. Hitchc.	not in Utah	remove from list
Sclerocactus pubispinus (Engelm.) L. Benson	Box Elder, Beaver, Sevier, Millard	no change
Senecio dimorphophyllus Greene var. *intermedius* Barkley	San Juan	no change
Silene petersonii Maguire var. *petersonii*	Sanpete	no change
Viola charlestonensis Baker & Clausen	Washington	no change

thorniae var. *gracilior,* the species becomes rather broadly distributed in a series of interconnected populations, which are hardly threatened.

Astragalus oorphorus var. **lonchocalyx.**— Previously known from only a single locality in western Iron County, the taxon is now known from several localities in Iron, and in Beaver County also. Additionally, the species is locally common in Lincoln County, Nevada.

Castilleja scabrida.— This species was placed on the list by oversight. It is a widely distributed paintbrush, flowering early in the growing season, and rivaling *C. chromosa* in abundance.

Camissonia parryi.— This plant has a restricted distribution, occurring only in Washington County, Utah. It is hardly rare, however. When the water regimen is conducive, this species grows in great abundance.

Corydalis caseana.— The distribution of this taxon indicates that it is rather widespread, although only locally common. It is not known to be threatened at the present time.

Cymopterus basalticus.— While the range of this species is known from Millard County only, that county is one of the largest in Utah. And, *C. basalticus* is broadly distributed in the western portion of that county. Indeed, the plants are common to abundant in much of the region.

Cymopterus newberryi.— This is another example of a plant which should not have been placed on the list. The broad range of this common plant has been known for many years.

Cymopterus rosei.— The plant remains rather obscure, but even fragmentary records demonstrate an extensive range for the entity.

Erigeron garrettii.— The Garrett fleabane daisy has a wide area of distribution in the northern and central Wasatch Range.

Eriogonum viridulum.— The range of *E. viridulum* is known to extend for more than 100 miles across the east-west axis of the Uinta Basin.

Geranium marginale.— The plateau geranium is a common plant over a broad section of south central Utah.

Gilia mcvickerae.— While occurring in disjunct populations, often on peculiar soils (either modified volcanics or calcareous gravels), the current knowledge indicates that the plants are widespread.

Haplopappus scopulorum.— A plant of protected coves in sandstone, this species has a broad range which defies classification as threatened.

Lupinus marianus.— This represents a portion of the variation within *L. sericeus*, with which it grades. The distribution of *L. marianus* in its narrowest sense is known to be more than 60 miles in length.

Machaeranthera grindelioides var. **depressa.**— This plant is widespread on knolls and ridges in western Millard, Tooele, and Beaver counties, where it is locally common to abundant.

Nama retrorsum.— The distribution of *N. retrorsum* precludes classification as threatened.

Opuntia whipplei var. **multigeniculata.**— This is a taxonomically questionable and obscure unit. The plants should be removed from the threatened category pending additional research.

Penstemon abietinus.— Large poulations of this taxon are present within its rather broad range.

Penstemon caespitosus var. **suffruticosus.**— The populations of this entity, which has a rather broad distribution on volcanic gravels, seem to be enhanced by disturbance, either natural or artificial. Hence, roadcuts and slide areas support viable stands of this pioneer plant.

Penstemon leiophyllus.— Collections of *P. leiophyllus* are so numerous and from such a broad area, that one has difficulty in ascertaining how it could be threatened.

Peteria thompsonae.— An unusual and interesting plant of broad distribution, this plant is locally common or even abundant. There is no reason to list it as threatened.

Phacelia constancei.— Known from divers populations over much of southern Utah, there seems to be little justification for keeping this handsome plant on the list.

Phacelia demissa var. **heterotricha.**— Though disjunct, this variety does not seem to be threatened in any portion of its range.

Phacelia rafaelensis.— The problem of range is the same as with *P. constancei.* It is too broadly distributed to be treated as threatened.

Phlox grahamii.— The type, and only known collection of *P. grahamii*, is a teratological specimen of what is presumed to be *P. longifolia.* Aecial sori of a rust are evident on the leaves and stem of the specimen, and distortion of vegetative and floral parts are in keeping with that observed in other diseased plants.

Phlox jonesii.— The type of *P. jonesii* appears to represent little more than a shade form of *P. austromontana,* and certainly belongs within the limits of that species.

Primula specuicola.— While of great interest from a phytogeographical sense, *P. specuicola* is found in too many sites to be classed as threatened. This is true even though one stronghold of the species has been eradicated by the rising waters of Lake Powell. The plant has almost an identical distribution as that of *Mimulus eastwoodiae.*

Puccinellia parishii.— There is no evidence to support the presence of this entity in Utah.

Scelerocactus spinosior.— Indications of the relationship of this plant with *S. whipplei*, in a broad sense, require a reevaluation of this entity which, though somewhat obscure, seems to be rather broadly distributed.

Candidate Endangered Species

There are four taxa which require consideration as endangered species. Of these, only one was known at the time when initial lists were prepared (Table 3). That one, *Lesquerella tumulosa*, had been placed into synonymy with a related species, *L. rubicundula.* In the judgment of this writer, *L. tumulosa* is distinct morphologically, spatially, and substrate-wise from *L. rubicundula.* The two plants are separated by about 900 meters in elevation. They flower at different times, with the low elevation *L. tumulosa* completing flowering at about the time *L. rubicundula* begins. *Lesquerella*

TABLE 3. Candidate endangered species not currently on Federal Register lists (1975, 1976), their locality by county in Utah, and justification based on present data.

Endangered Plants (Proposed)	Locality	Justification
Astragalus montii Welsh	Sanpete	Local; restricted to limestone; high elevation
Eriogonum corymbosum Benth. var. *Matthewsae* Reveal	Washington	Local; restricted to mud-siltstone; low elevation
Lesquerella tumulosa (Barneby) Reveal	Kane	Local; restricted to limy mudstone; low elevation
Thelypodiopsis argillacea Welsh & Atwood	Uintah	Local; restricted To oil shale; moderate elevation

tumulosa is known from white calcareous shales of the Winsor member of the Carmel Formation, and *L. rubicundula* occurs on the Wasatch limestone sequence. Further, the pluricipital, pulvinate growth with a great many inflorescences per plant is not known for *L. rubicuncula*, but is characteristic of the population of *L. tumulosa*.

The remaining candidate endangered species are all newly described or undescribed. They are as follows:

Astragalus montii Welsh sp. nov.— *Astragalo limnochari* Barneby aemulans differt in floribus magnioribus et purpureis et foliolis non ciliatis. Plantae perennes, acaulescentes, 1–5 cm altae, caudicibus ramificantibus enanescentibus; pubescentiae basifixae; stipulae 2–4 mm longae totus connatae-vaginantes; foliola 1.3–4.8 cm longa: foliola 5–13, 2–8 mm longa 1–2 mm lata lanceolata oblonga vel elliptica strigosa infra non ciliata ad marginem glabra supra; pedunculi 0.8–4.5 cm longi in fructum reclinatum; racemi 2- to 8-floribus, floribus ascendentibus vel patentibus ad anthesin, axibus 0.2–0.5 cm longis in fructum; bracteae 1–3 mm longae; pedicelli 0.8–1.4 mm longi; bracteolae nullae; calyx 3.3–4 mm longus, tubo 2.2–2.5 mm longo campanulato strigoso, dentibus 0.6–1.5 mm longis triangularibus vel subulatis; flores 7.2–8 mm longi purpurei, ala apicis albis; legumina patentia sessilia ovoidea vesicaria 11–18 mm longa 8–12 mm lata maculosa uniloculari; ovula 10. Holotype: Utah, Sanpete Co., ca 17 miles due west of Ferron, Flagstaff Limestone, marly barrens, at 3,350 m, S. L. & Jean Welsh 15404, 13 July 1977 (BRY, isotopes to be distributed). Paratypes: Utah, Sanpete Co., M. E. Lewis 4312, 23 July 1976; do, M. E. Lewis 4775, June 1977 (both at BRY). *Astragalus montii* is a near congener of *A. limnocharis* from which it is isolated geographically by some 225 km. Both are low-growing calciphiles occurring on limestone gravels at high elevations. They agree further in general aspect and in having small flowers giving rise to bladdery-inflated unilocular pods. The flowers differ in color, and those of *A. montii* average larger in size. The striking long hair which margin the leaves of *A. limnocharis* are lacking in *A. montii*. The species is named to honor Mont E. Lewis, extraordinary plant collector, and codiscoverer of the plant along with Robert Thompson.

Eriogonum corymbosum var. matthewsae.— The only known population of this buckwheat variety occurs at the mouth of Zion Canyon on the Chinle Formation. Roadways, power lines, and other developments on the slope where the plants occur threaten its existence. Certainly, this plant has the characteristics of an endangered species.

Thelypodiopsis argillacea.— The Green River Shale formation serves as substrate for many unusual species of plants. Thus, it is not unexpected that still another narrow endemic be located on that formation. The species was located while searching for *Glaucocarpum suffrutescens*, another rare plant of Green River Shale. Subsequent investigation of the type area indicated that

T. argillacea is narrowly restricted. The small population is known at present from a single north-facing slope. Based on that information, and given the potential for development of oil shale, *T. argillacaca* has the features of an endangered plant.

CANDIDATE THREATENED SPECIES

There are several species and varieties of very limited distribution which were overlooked or unnamed at the time when the original lists of species were proposed as threatened. The candidates for inclusion on the threatened list for Utah is presented in Table 4. Justification for inclusion is presented below.

Astragalus castaneiformis var. consobrinus.— This is an obscure tiny plant of volcanic gravels with its main locus in Rabbit Valley, Wayne Co., where it is only locally common. Further materials might dictate its removal from the list.

Astragalus henrimontanensis (Welsh, nom. nov. based on *Astragalus stocksii* Welsh Great Basin Nat. 34:307. 1974.— The Dana milkvetch is known from the Henry Mountains only. It is restricted to an elevational range corresponding to the ponderosa pine belt in the Penellen Pass vicinity. Total extent of the population based on current information is through approximately six miles of the eastern flank of Mount Pennell. Development of any kind, including

TABLE 4. Candidate threatened species not currently on Federal Register lists (1975, 1976), their locality by county in Utah, and justification based on present data.

Threatened Plants (Proposed)	Locality	Justification
Astragalus castaneiformis S. Wats. var. *consobrinus* Barneby	Garfield, Piute, Sevier, Wayne	Local; volcanic gravel
Astragalus limnocharis Barneby	Iron, Kane	Local; calciphile; high elevation
Astragalus henrimontanensis Welsh	Garfield	local; montane endemic
Astragalus monumentalis Barneby	Garfield, San Juan	Local; Cedar Mesa Sandstone endemic
Astragalus sabulosus M.E. Jones	Grand	Local; Mancos Shale endemic
Cymopterus higginsii Welsh	Kane	Local; Tropic Shale endemic
Dalea epica Welsh	San Juan	Local; Navajo Sandstone endemic
Draba maguirei C.L. Hitchc.	Cache, Weber	Local; montane endemic
Eriogonum natum Reveal	Millard	Local; lacustrine terrace endemic
Gaillardia flava Rydb.	Grand, Emery	Local; Mancos Shale endemic
Hedysarum boreale Nutt. var. *gremiale* (Rollins) Northstrom & Welsh	Uintah	Local; Bishop Conglomerate endemic
Helianthus deserticolus Heiser	Washington	Local; sand dune endemic
Hymenoxys depressa (Torr. & Gray) Welsh & Reveal	Emery, Garfield, Uintah (?)	Local; Silicious conglomerate, very restricted
Lepidium montanum Nutt. var. *neeseae* Welsh & Reveal	Garfield	Local; Navajo Sandstone endemic
var. *stellae* Welsh & Reveal	Kane	Local; Windsor endemic
Lomatium latilobum (Rydb.) Mathias	Grand, San Juan	Local; Entrada Sandstone endemic
Lupinus jonesii Rydb.	Washington	Local; sandstone and alluvial endemic
Machaeranthera glabriuscula (Nutt.) Cronq. & Keck var. *confertifolia* Cronq.	Garfield, Kane	Local; Kaiparowits Endemic
Machaeranthera kingii (D.C. Eaton) Cronq. & Keck	Cache, Salt Lake, Utah	Disjunct, local; calciphile

Table 4.— contd.

Threatened Plants (Proposed)	Locality	Justification
Mentzelia argillacea Darlington	Sevier	Local; Arapien Shale endemic
Musineon lineare (Rydb.) Mathias	Cache	Local; lacustrine terrace endemic
Najas caespitosa (Maguire) Reveal	Sevier	Local; endemic to Fish Lake
Penstemon atwoodii Welsh	Garfield, Kane	Local; Kaiparowits vicinity endemic
Penstemon bracteatus Keck	Garfield	Local; Wasatch endemic
Penstemon humilis Nutt. var. *Obtusifolius* (Pennell) Reveal	Washington	Local; Navajo Sandstone endemic
Penstemon tidestromii Pennell	Juab, San Pete	Local; Sanpitch Mountains endemic
Psoralea pariensis Welsh & Atwood	Garfield, Kane	Local; Bryce Canyon—Paria drainage endemic
Silene petersonii Maguire var. *minor* Hitchc. & Maguire	Garfield, Iron	Local; Wasatch endemic
Sphaeralcea caespitosa M.E. Jones	Beaver, Millard	Local; Wah Wah—Pine Valley endemic
Thelypodium sagittatum (Nutt.) Endl. var. *ovalifolium* (Rydb.) Welsh & Reveal	Garfield, Iron	Local; Markagunt Plateau endemic
Townsendia mensana M.E. Jones	Duchesne, Uintah	Local; Uinta Basin endemic
Townsendia minima Eastw.	Garfield, Kane	Local; Wasatch endemic
Xanthocephalum sarothrae (Pursh) Shinners var. *pomariense* (Welsh) Welsh	Uintah	Local; Ashley Valley—Green River endemic

reclamation of lands in range improvement attempts, could result in loss of substantial portions of the population.

Astragalus limnocharis.— The Navajo Lake milkvetch is known mainly from the gravelly shore of the lake. Dispersal of the bladdery pods is apparently by wind and by water. The plants tend to occur in rows along minor wave-cut terraces in the beach. A dam extends across the lake basin, limiting the water to the west end of the lake, except in peak years. The milkvetch species does not now occur in the portion of the basin from which the lake has been excluded. A secondary location has been reported in the Cedar Breaks vicinity, a short distance to the northwest of the Navajo Lake locus.

Astragalus monumentalis.— The Monument milkvetch is known from Natural Bridges National Monument westward along the Cedar Mesa Sandstone to where that formation dips beneath other strata west of the Colorado River Canyon in easternmost Garfield County, and north to the Chesler Park region of Canyonlands National Park. Any development on that formation could result in loss of portions of the total population, and require change of status to endangered.

Astragalus sabulosus.— This plant is known only from the vicinity of Thompson east to Cisco, and possibly south as far as the banks of the Colorado River in that general vicinity. All modern collections are from Mancos Shale, but early collections by Jones presumably came from Morrison or Cedar Mountain formations near the river. Even in optimum seasons of growth for this handsome large-flowered selenophyte the number of plants in the known populations is small. Only a few dozen plants have ever been observed by the writer in several years of observation. The plant has very large ochroleucous flowers which distinguish this plant easily from the similar *A. praelongus*, with which it grows. The entire known range of the species is in northcentral Grand County.

Atriplex welshii.— The Welsh saltbush is a local species of the Mancos Shale a few miles southwest of Cisco in Grand County. It is a restricted plant of the Mancos Shale, in a region where few plants occur on the formation. Other local species are known from the vicinity, and perhaps the entire range of the species should be considered for preservation.

Cymopterus higginsii.— A plant with lavender flowers, *C. higginsii,* is known from the Tropic Shale (Tununk equivalent) from the vicinity of Coyote Creek east to Smoky Mountain in eastern Kane County. The area is being subjected to heavy use by off-highway vehicles, and other anticipated activities along with that use might jeopardize portions of the population, which is only locally common in the region.

Dalea epica.— The Hole-in-the-Rock prairie clover is known from a small population on Navajo Sandstone some distance east of Halls Crossing in San Juan County. The population has been interpreted by R. C. Barneby (personal communication) as a portion of *D. flavescens,* to which it is undoubtedly closely allied. The population deserves preservation, even if it is only an exclusive phase within the total variation of that species. The taxon is recognized at species level by Welsh (1977) in a treatment of the legumes of Utah, which is in preparation.

Draba maguirei.— This entity, in a broad sense, is very restricted to mountain summits in a small portion of the northern Wasatch Range.

Eriogonum natum.— This wild buckwheat is a narrow endemic of Lake Bonneville lacustrine deposits in Millard County. The total known area of the population is very small. It is worthy of being regarded as threatened.

Gaillardia flava.— A smelly, resinous plant of canyon bottoms in portions of the Mancos Shale, this handsome yellow blanketflower has long remained obscure. Total range is over a region only about 20 miles in length.

Hedysarum boreale var. **gremiale.**— An unusual phase of *H. boreale* with spinulose projections along the reticulations of the fruit, this plant occurs in west central Uintah County. The plants apparently grade with the more typical *H. boreale* materials in the region. However, this is the only known taxon of American *Hedysarum* species with spinulose projections. The population is poorly known, and further work is needed to elucidate the total area involved.

Helianthus deserticolus.— This sand-inhabiting sunflower is known to occur in a limited low-elevation portion of Washington County. More information is necessary to understand the total limits of the taxon and to clarify its relationship to *H. anomalus* Blake.

Hymenoxys depressa.— Although first named by Gray (1849), this plant has remained obscure. The type was taken by Fremont on his second expedition, possibly in the Uinta Basin of Utah.

Lepidum montanum var. **neeseae.**— This tiny phase of the polymorphic *L. montanum* is known from high elevations on Navajo Sandstone only.

Lepidium montanum var. **stellae.**— The Stella Lepidium grows with *Lesquerella tumulosa* on the Winsor formation in western Kane County.

Lomatium latilobum.— The broad-lobed biscuitroot is a narrow endemic of sandy soils, usually at the base of monoliths in Entrada Sandstone in south central Grand and north central San Juan counties. The species is only locally common. Development of those regions might cause the species to become endangered.

Lupinus jonesii.— The Jones lupine inhabits sandy and calcareous soils of central and western Washington County. The species has long remained obscure, and much more information should be gathered prior to final disposition of this taxon.

Machaeranthera glabriuscula var. confertifolia.— The total area occupied by this handsome white-flowered daisy is confined to the gray colluvial and in situ soils of the Kaiparowits formation. The plants grow on crests and eroded flats of that formation, generally within the juniper-pinyon woodland. The formation is local in the northern portion of the Kaiparowits Plateau vicinity, and it might be endangered by proposed and future developments.

Machaeranthera kingii.— Much more information is required to assess the total range of *M. kingii*, but indications are that the plant is restricted to limestone outcrops in the mountains of Cache, Salt Lake, and Utah counties. Collections and known localities of the plant are few.

Mentzelia argillacea.— The clay blazing star is restricted to Arapien Shale and alluvium derived from that formation and others adjacent to it. Total area is apparently from near Monroe on the south to Salina on the north. Mining for gypsum and other minerals shrinks the area occupied by this distinctive plant each year.

Musineon lineare.— This species is known from a localized portion of Cache County, which is being impressed by construction and other activities.

Najas caespitosa.— Fish Lake is the only known habitat of this aquatic plant. The relationship apparently lies with more widespread species in the genus. Until the relationship is clarified, it is best to consider these unusual plants as threatened.

Penstemon atwoodii.— The Atwood beardtongue has a similar but smaller range than *Astragalus malacoides*. Both are confined to the Straight Cliffs and associated formations on the Kaiparowits Plateau and vicinity. Prospective development of resources in the Kaiparowits could result in eradication of portions of the population and might lead to endangered classification.

Penstemon humilis var. obtusifolius.— Confined to Navajo sandstone and alluvium derived from that formation, this remarkably low beardtongue is known only from eastern Washington County.

Penstemon tidestromii.— Long obscure, the Tidestrom beardtongue is known only from the Sanpitch Mountains in eastern Juab and Sanpete counties.

Psoralea pariensis.— The few known populations of the Paria scurfpea occur on Wasatch Limestone and alluvium derived from the formation, or less commonly on sandstone and sandy alluvium. Many more collections might indicate a rather broader range and require a reevaluation of the threatened status.

Silene petersonii. var. minor.— Endemic to limestone members of the Wasatch Formation, this variety of the striking *S. petersonii* is known from small populations located in two main areas. The type locality is at Red Canyon in Garfield County, and the other main locus is at Cedar Breaks.

Sphaeralcea caespitosa.— The Jones globe mallow has a similar area of occupation as does *Penstemon concinnus* and *P. nanus*, but it does not always occur with those species. Portions of western Millard and Beaver counties not inundated by Lake Bonneville seem to be the primary areas occupied by this beautiful plant.

Thelypodium sagittatum var. ovalifolium.— This peculiar plant is known from the vicinity of Panguitch Lake in western Garfield and adjacent Iron counties. The populations are poorly known, indicating a need for much additional information.

Townsendia mensana.— The range of *T. mensana* is only generally known. The status of the species should be indicated as threatened until such a time that this entity is demonstrated to be more common than currently indicated.

Townsendia minima.— The least townsendia is known from the white and pink limestone members of the Wasatch Formation. Usually, the plants occur in narrow bandlike strips along the margin of breaks and ridge tops on the formation.

Distribution by County

Federal agencies and others interested in development of lands in Utah require information on proposed endangered and threatened plant distribution so that decisions on land use can be made. The summary lists presented below will allow interested parties to determine whether more specific investigations will be necessary. The lists reflect the recommended changes indicated in the present paper.

Beaver County
Castilleja parvula (T)
Penstemon concinnus (T)
Penstemon nanus (T)
Sclerocactus pubispinus (T)
Sphaeralcea caespitosa (T)

Box Elder County
Allium passeyi (E)

Eriogonum nanum (T)
Sclerocactus pubispinus (T)

CACHE COUNTY
Draba maguirei (T)
Erigeron cronquistii (T)
Eriogonum loganum (E)
Machaeranthera kingii (T)
Musineon lineare (T)
Penstemon compactus (T)
Primula maguirei (T)

CARBON COUNTY
Eriogonum corymbosum
  var. davidesei (E)
Eriogonum lancifolium (E)
Lygodesmia grandiflora
  var. stricta (E)

DAGGETT COUNTY
Arabis demissa
  var. lanugida (T)
  var. russeola (T)
Cryptantha stricta (T)
Mertensia viridis
  var. dilatata (T)
Parrya rydbergii (T)
Penstemon acaulis (T)
Penstemon uintahensis (T)

DUCHESNE COUNTY
Astragalus detritalis (T)
Astragalus duchesnensis (T)
Cymopterus duchesnensis (T)
Eriogonum hylophilum (E)
Lepidium barnebyanum (E)
Parrya rydbergii (T)
Penstemon garrettii ? (E)
Sclerocactus glaucus (E)
Townsendia mensana (T)

EMERY COUNTY
Asclepias ruthiae (T)
Astragalus rafaelensis (T)
Cryptantha jonesiana (T)
Cryptantha johnstonii (E)
Erigeron maguirei (E)
Eriogonum intermontanum (E)
Eriogonum smithii (E)
Euphorbia nephradenia (T)
Festuca dasyclada ? (PoEx)
Gaillardia flava (T)
Hymenoxys depressa (T)
Sclerocactus wrightiae (E)

GARFIELD COUNTY
Astragalus barnebyi (T)
Astragalus castaneiformis
  var. consobrinus (T)
Astragalus henrimontanensis (T)
Astragalus malacoides (T)
Astragalus monumentalis (T)
Astragalus perianus (T)
Castilleja aquariensis (E)
Castilleja revealii (E)
Cryptantha ochroleuca (E)
Eriogeron abajoensis (T)
Eriogonum aretioides (E)
Eriogonum corymbosum
  var. revealianum (T)
Eriogonum cronquistii (E)
Draba sobolifera (T)
Draba subalpina (T)
Heterotheca jonesii (E)
Hymenoxys depressa (T)
Lepidium montanum
  var. neeseae (T)
Lesquerella rubicundula (T)
Lomatium minimum (T)
Machaeranthera glabriuscula
  var. confertiflora (T)
Penstemon atwoodii (T)
Penstemon bracteatus (T)
Penstemon parvus (T)
Phlox gladiformis (T)
Psoralea pariensis (T)
Silene petersonii
  var. minor (T)
Ranunculus acriformis
  var. aestivalis (PoEx)
Thelypodium sagittatum
  var. ovalifolium (T)
Townsendia minima (T)

GRAND COUNTY
Asclepias cutleri (T)
Asclepias ruthiae (T)
Astragalus iselyi (E)
Astragalus sabulosus (T)
Atriplex welshii (T)
Cryptantha elata (T)
Cycladenia humilis
  var. jonesii (E)
Erigeron mancus (T)
Gaillardia flava (T)
Lomatium latilobum (T)
Phacelia howelliana (T)

IRON COUNTY
Astragalus lentigenosus
  var. ursinus ? (PoEx)
Astragalus limnocharis (T)
Cymopterus minimus (E)
Draba subalpina (T)
Erigeron flagellaris
  var. trilobatus (E)
Eriogonum panguicense
  var. alpestre (T)
Lomatium minimum (T)
Phlox gladiformis (T)
Silene petersonii
  var. minor (T)
Thelypodium sagittatum
  var. ovalifolium (T)

JUAB COUNTY
Cymopterus coulteri (T)
Penstemon tidestromii (T)

KANE COUNTY
Astragalus ampullarius (T)
Astragalus lancearius (T)
Astragalus limnocharis (T)
Cymopterus higginsii (T)
Draba subalpina (T)

Erigeron abajoensis (T)
Erigeron religiosus (E)
Eriogonum jamesii
  var. rupicola (T)
Eriogonum thompsonae
  var. thompsonae (T)
Euphorbia nephradenia (T)
Hymenopappus filifolius
  var. tomentosus (T)
Lepidium montanum
  var. stellae (T)
Lesquerella rubicundula (T)
Lesquerella tumulosa (E)
Lomatium minimum (T)
Machaeranthera glabriuscula
  var. confertiflora (T)
Penstemon atwoodii (T)
Phacelia cephalotes (T)
Phacelia mammillariensis (E)
Psoralea epipsila (E)
Psoralea pariensis (T)
Townsendia minima (T)
Viguiera soliceps (E)
Zigadenus vaginatus (T)

MILLARD COUNTY
Astragalus callithrix (E)
Cryptantha compacta (T)
Cuscuta warneri (PoEx)
Eriogonum ammophilum (E)
Eriogonum eremicum (T)
Eriogonum natum (T)
Penstemon concinnus (T)
Penstemon nanus (T)
Penstemon parvus (T)
Sclerocactus pubispinus (T)

PIUTE COUNTY
Astragalus castaneiformis
Astragalus perianus (T)
Eriogonum corymbosum
  var. revealianum (T)
Castilleja parvula (T)
Draba sobolifera (T)
Eriogonum ostlundii (T)
Lesquerella rubicundula (T)

SALT LAKE COUNTY
Lesquerella garrettii (T)
Machaeranthera kingii (T)

SAN JUAN COUNTY
Asclepias cutleri (T)
Astragalus cottamii (T)
Astragalus cronquistii (E)
Astragalus iselyi (E)
Astragalus monumentalis (T)
Dalea epica (T)
Erigeron abajoensis (T)
Erigeron kachinensis (E)
Erigeron mancus (T)
Eriogonum clavellatum (T)
Eriogonum humivagans (E)
Lomatium latilobum (T)
Phacelia howelliana (T)
Phacelia indecora (E)
Senecio dimorphophyllus
  var. intermedius (T)

SANPETE COUNTY
Astragalus desereticus (PoEx)
Astragalus montii (E)
Festuca dasyclada (PoEx)
Penstemon tidestromii (T)
Penstemon wardii (T)
Phacelia utahensis (T)
Silene petersonii
  var. petersonii (T)

SEVIER COUNTY
Astragalus castaneiformis
  var. consobrinus (T)
Cymopterus coulteri (T)
Eriogonum ostlundii (T)
Mentzelia argillacea (T)
Najas caespitosa (T)
Penstemon wardii (T)
Phacelia utahensis (T)
Sclerocactus pubispinus (T)
Townsendia aprica (E)

SUMMIT COUNTY
Cryptantha stricta (T)
Mertensia viridis
  var. cana (T)
Parrya rydbergii (T)

UINTAH COUNTY
Arabis demissa
  var. russeola (T)
Astragalus detritalis (T)
Astragalus duchesnensis (T)
Astragalus hamiltonii (T)
Astragalus lutosus (E)
Astragalus saurinus (T)
Cryptantha barnebyi (E)
Cryptantha grahamii (E)
Cryptantha stricta (T)
Eriogonum ephedroides (T)
Eriogonum intermontanum (E)
Eriogonum saurinum (T)
Glaucocarpum suffrutescens (E)
Hedysarum boreale
  var. gremiale (T)
Hymenoxys depressa ? (T)
Lepidium barnebyanum ? (E)
Parrya rydbergii (T)
Penstemon grahamii (E)
Penstemon uintahensis (T)
Sclerocactus glaucus (E)
Thelypodiopsis argillacea (E)
Townsendia mensana (T)

UTAH COUNTY
Cymopterus coulteri (T)
Lesquerella garrettii (T)
Machaeranthera kingii (T)
Phacelia argillacea (E)

WASATCH COUNTY
Lesquerella garrettii (T)
Penstemon garrettii (PoEx)

WASHINGTON COUNTY
Arctomecon humilis (T)
Astragalus ampullarius (T)
Astragalus ensiformis (T)
Cryptantha semiglabra (T)
Draba zionensis (T)
Echinocereus engelmannii
  var. purpureus (E)
Epilobium nevadense (T)
Erigeron religiosus (E)
Erigeron sionis (E)
Eriogonum corymbosum
  var. matthewsae (E)
Eriogonum jamesii
  var. rupicola (T)
Eriogonum thompsonae
  var. albiflorum (T)
  var. thompsonae (T)
Eriogonum zionis (T)
Helianthus deserticolus (T)
Heterotheca jonesii (E)
Hymenopappus filifolius
  var. tomentosus (T)
Lupinus jonesii (T)
Pediocactus sileri (E)
Penstemon humilis
  var. obtusifolius (T)
Phacelia anelsonii (T)
Phacelia cephalotes (T)
Phlox gladiformis (T)
Viola charlestonensis (T)

WAYNE COUNTY
Asclepias ruthiae (T)
Astragalus barnebyi (T)
Astragalus castaneiformis
  var. consobrinus (T)
Astragalus harrisonii (E)
Euphorbia nephradenis (T)
Gilia caespitosa (E)
Phacelia indecora (E)
Sclerocactus wrightiae (E)

WEBER COUNTY
Draba maguirei (T)
Eriogonum nanum (T)

LITERATURE CITED

GRAY, A. 1849. Plantae Fendlerianae Nove-Mexicanae. Mem. Am. Acad. 4:1–116.

WELSH, S. L. 1976. Proposed threatened, endangered, presumed extinct, or extinct and disjunct relict plants in the Cedar City and Richfield districts, Utah. Final Report, Bureau of Land Management, unpublihed ms. 205 pp.

______. 1977a. Endangered and threatened plant species of the Central Coal Land, Utah. Final Report, Interagency Task Force on Coal, U.S. Geological Survey. 422 pp.

______. 1977b. Endangered and threatened plant species of the Southern Coal Lands, Utah. Final Report, Interagency Task Force on Coal, U.S. Geological Survey. 415 pp.

WELSH, S. L. AND N. D. ATWOOD. 1977. An undescribed species of *Thelypodiopsis* (Brassicaceae) from the Uinta Basin, Utah. Great Basin Nat. 37:95–96.

WELSH, S. L., N. D. ATWOOD, AND J. L. REVEAL. 1975. Endangered, threatened, extinct, endemic and rare or restricted Utah vascular plants. Great Basin Nat. 35:327–376.

PLANTS OF NAVAJO NATIONAL MONUMENT

J. D. Brotherson,[1] G. Nebeker,[2]
M. Skougard,[3] and J. Fairchild[1]

Abstract.— The floristic composition of Navajo National Monument is presented. The flora of the monument consists of 293 species of vascular plants, representing 177 genera and 66 families. The species are scattered throughout 12 plant communities found within the monument. The flora is dominated by forbs (60 percent), followed by shrubs (16 percent), grasses (12 percent) and trees (5 percent). Betatakin canyon exhibits the greatest floristic richness with 223 species being represented and 123 species found only in that area. This is due primarily to two factors: (1) the greater variety of habitats available in the area, and (2) the much longer time the area has been protected from grazing and other manmade disturbance.

Navajo National Monument is in northeastern Arizona about 10 miles north and west of Black Mesa and Arizona Highway 160. The park headquarters are located on the Shonto Plateau near the head of Betatakin Canyon, a small side canyon of Tsegi Canyon. The principle attractions of the monument are three large Indian "cliff dwellings" of the Anasazi culture. These cliff dwellings are located in three separate canyons. Betatakin and Keet Seel canyons are located in the Tsegi Canyon complex, while Inscription House is situated about 20 miles west of Betatakin in Nitsin Canyon, a branch of Navajo Canyon.

All three units lie in pinyon-juniper slickrock country which tends to influence heavily the environment of the monument. In the region are many deep-cut canyons with high-walled sandstone cliffs often reaching heights of 1000 feet above the streambeds. Within these deep canyons and along their walls, water (in the form of springs and seeps) is often present, creating unique habitats in which develop plant and animal communities often foreign to the overall pinyon-juniper type.

Because of the historical background of the park, almost all previous studies conducted at Navajo National Monument have been archaeological in nature. Dean (1969) points out that up to that time no botanical studies of Tsegi Canyon and its environs had been completed. Apparently, he was referring to the vascular flora, since Flowers (1963) published a study on the lichens and mosses of Betatakin Canyon and vicinity. In his introduction, Flowers (1963) briefly lists some of the dominant plant species in and around Betatakin Canyon. Woodbury (1963) at the request of the National Park Service studied the features of Betatakin Canyon and vicinity for their interpretative value and use by the park personnel. His treatment is cursory and brief.

Climate

Climatically, Navajo National Monument lies within the northeast sector of Arizona (Sellers 1964). There is a weather station at the park headquarters. Temperature and precipitation data for this station have appeared in *Climatalogical Data*, Arizona (U.S. Dept. of Commerce), since 1939.

The average annual temperature at Navajo National Monument headquarters is 50 F. The yearly maximum temperatures range from 94 to 101 F with an average of 96.1 F. The yearly low temperatures range from −10 to +8 F with an average of 1 F. The frost-free season ranges from 107 to 213 days with an average of 155 days.

The total annual precipitation at Betatakin has historically ranged from a low of 6.84 inches to a high of 18.79 inches with an average of 11.39 inches. The period of greatest precipitation is late summer and early fall. Rainfall within the canyons is variable and spotty, with localized cloudbursts occurring more often than general rains.

---

[1] Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602.
[2] Department of Botany and Microbiology, Arizona State University, Tempe, Arizona 85281.
[3] United States Department of Agriculture, Houston, Texas.

GEOLOGY

The geology of Tsegi Canyon has been treated by a number of authors (Gregory 1916, 1917; Hack 1942, 1945; Harshbarger, Repenning, and Irwin 1957; Cooley 1958, 1962). Navajo Sandstone is the major geological formation in each of the three localities. At Keet Seel and Inscription House the Navajo Sandstone is the only exposed rock formation. At Betatakin the Kayenta formation outcrops beneath the Navajo formation and can be observed in some locations in the lower reaches of the canyon. In all three canyons the Navajo Sandstone forms tall, rather sheer cliffs, up to 700 feet in height. At the base of these cliffs in each canyon, talus accumulations can be found, while the canyon bottoms are filled with deep deposits of sandy alluvium (quaternery fill). In Keet Seel and Nitsin Canyons these alluvial deposits are deeply eroded. In Betatakin Canyon the alluvial deposits are less extensive and not nearly so thick. They are underlain by the Kayenta formation in the lower half of the canyon and are deeply eroded, as is more characteristic of the canyon floor throughout the Tsegi Canyon system.

PLANT COMMUNITIES

In line with the unique geological and habitat features of Navajo National Monument, the communities within its boundaries are varied and in some cases unique. Twelve community (association) types (Table 1) are encountered within the monument. Of these only one (Pinyon-Juniper mixed shrub) is found in all segments of the monument. Five of the remaining 11 community types are found in 2 of the monument areas while 6 of the types are restricted to a single segment.

Because of the uniqueness of the Betatakin Canyon area, the vegetation there is highly different and distinct when compared with adjacent Tsegi Canyon and surrounding areas. Of special note is the presence in the canyon of a complex of species (i.e., *Populus tremuloides*, *Pseudotsuga menziesii*, *Mahonia repens*, *Symphoricarpos vaccinoides*, etc.) more often associated with high mountain rather than desert habitat. These species are found in the canyon because of favorable moisture regimes created by the canyon geology and Navajo Sandstone hydrology.

Flora of the Monument

The known flora of Navajo National Monument consists of 293 species of vascu-

TABLE 1. Vegetative communities (associations) encountered within the boundaries of Navajo National Monument and the percent of area they occupy.

Vegetation type	Monument segment		
	Inscription House	Keet Seel	Batatakin
	Percent of area covered	Percent of area covered	Percent of area covered
Streamside-tree	1.8		
Slickrock-scattered shrub	35.0	12.6	
Atriplex-grass	25.9	0.2	
Talus slope	11.3	9.3	
Mixed weed		13.5	
Pinyon-juniper-mixed shrub	26.0	59.6	43.5
Oak		4.8	2.4
Hanging garden		**T	T
Pinyon-juniper-sage			49.9
Pinyon-juniper-grass			3.1
Douglas Fir			0.4
Aspen			.7

*Total acreage equals:
Inscription House = 40
Keet Seel = 40
Betatakin = 452
**T = trace

lar plants, representing 177 genera and 66 families. Of these species, 73 percent belong to the plant families listed in Table 2. These figures indicate the relative plant family composition of the monument. When comparisons are made with other studies (Brotherson 1967, Campbell 1977, Allan 1977) done in somewhat comparable areas of the Great Basin (Table 2), 7 of the 17 plant families listed are found to be represented in the floras of all 4 locations. As can be seen from the table, Arches National Park (Allan 1977) is the most similar in its dominant family composition to that of Navajo National Monument, differing only in 5 of the 17 families listed. The studies done in the Uintah Basin and Kaiparowits areas show high degrees of similarity to each other, differing only in one major plant family as well as being dominated by 9 of the 17 plant families listed in the table. In light of these facts it is of interest to note that the Navajo National Monument and Arches National Park areas have as their major geological formations sandstone while the Kaiparowits and Uintah Basin study areas are underlain mainly by geological formations high in clay. The ecological and/or phytogeographical significance of the dominance of these 17 plant families and/or their relationship to the general geology of the area is not known; however, further investigation along such lines tends to hold interest.

The species richness of the different segments of the Navajo National Monument is shown in Table 3. As can be seen, the Betatakin area exhibits more than twice as many species in its vegetation as can be found in the other areas. It also contains the greatest number of species found in only one of the monument areas. This would primarily be due to two factors: (1) the much longer time the area has been protected from grazing and other man-made disturbance, and (2) the greater variety of habitats available in the area.

The life-form and/or growth habitat characteristics of the flora are summarized in Tables 4 and 5. Native species number 270, 92.2 percent of the total flora. Twenty-three species are introduced. These include such species as *Tamarix ramosissima*, *Elaeagnus angustifolia*, *Chenopodium album*, *Salsola iberica*, *Sisymbrium altissimum*, *Melilotus alba*, and other species of a weedy nature. The herbaceous types of growth habit account for almost 75 percent of the species, with shrubs and trees contributing together about 20 percent of the total. In area coverage, however, the tree-

Table 2. Dominant plant family composition of Navajo National Monument and other great basin sites.

Family	Navajo National Monument	Kaiparowits	Arches National Park	Uintah Basin
Asteraceae	21.2	21.4	22.0	22.0
Poaceae	12.6	15.5	13.7	9.3
Brassicaceae	4.4	4.8	4.5	8.7
Fabaceae	4.4	4.8	6.9	5.8
Rosaceae	3.1		1.7	
Nyctaginaceae	3.1			
Cactaceae	3.1		1.7	
Boraginaceae	2.7	4.8	2.8	5.7
Polmoniaceae	2.7	8.3		4.0
Scrophulariaceae	2.7		2.8	5.7
Chenopodiaceae	2.4	10.7	6.6	5.8
Ranunculaceae	2.4			
Solanaceae	2.4			
Polygonaceae	2.0	4.8	3.3	5.7
Cyperaceae			1.9	
Liliaceae	2.0		1.9	
Salicaceae	2.0		1.7	
Total	73.2	75.1	71.5	72.7

and shrub-dominated vegetation types are the most widespread in the monument.

Checklist

The present list of plant species is the result of specimen collection at Navajo National Monument that has extended over a period of more than 45 years. Personnel associated with the park service began collections during the late 1930s and early 1940s. Scientists from Brigham Young University began work in the monument in the summer of 1972. Since that time regular visits have been made to the area and collections have been made throughout the growing season.

Table 3. Floristic richness of the different segments of Navajo National Monument.

Area of Monument	No. of species	No. of species found only at area in question
Betatakin	223	123
Keet Seal	108	16
Inscription House	108	31

Table 4. Plant characteristics and generalized life forms of the flora of Navajo National Monument.

Category	No. of species in category	Percent of total
Total no. of species	293	100.0
Native species	270	92.2
Introduced species	23	7.8
Perennial species	224	76.5
Biennial species	21	7.2
Annual species	48	16.4

Table 5. Growth habit characteristics of the flora of Navajo National Monument.

Category	No. of species in category	Percent of total
Trees	14	4.8
Shrubs	49	16.7
Forbs	176	60.1
Grasses	37	12.6
Sedges	4	1.4
Vines	1	.3
Other	12	4.1

Over the years the area has been visited and collections made by: M. Wetherill, 1930–1938; J. W. Brewer, 1934–1947; S. P. Brewer, 1941; E. Lehnert, 1960; E. Jackson, 1961; W. S. Phillips, 1964; J. M. Rominger, 1965; M. Skougard and G. Nebeker, 1972–1973; J. Brotherson, 1972–1977; and J. Fairchild, 1977. In the following list the specimens upon which the species are based are designated and the collectors' names abbreviated as indicated below:

MW	M. Wetherill
JWB	J. W. Brewer
SPB	S. P. Brewer
EL	E. Lehnert
EJ	E. Jackson
WSP	W. S. Phillips
JMR	J. M. Rominger
SN	M. Skougard and G. Nebeker
JF	J. Fairchild
JDB	J. D. Brotherson

Each species entry is also designated as to certain plant characteristics and according to the section of the monument in which it was found growing. These abbreviations are as follows:

P	Perennial
B	Biennial
A	Annual
N	Native
I	Introduced
T	Tree
S	Shrub
F	Forb
G	Grass
GI	Sedge
NV	Non-vascular
V	Vine
b	Betatakin
k	Keet Seel
i	Inscription House

The following list of families, genera, and species is arranged in alphabetical order for ease of reference. Plant identification follows *Arizona Flora* (Kearney and Peebles 1960), *Seed Plants of Northern Arizona* (McDougal 1973), *Manual of the Plants of Colorado* (Harrington 1964) and *Utah Plants* (Welsh and Moore 1973).

TAXA	PLANT CHARACTERISTICS
SUBDIVISION LYCOPSIDA	
Selaginella	
Selaginella mutica D. C. Eaton (WSP 3617, 19 June 1964)	PNNVb

SUBDIVISION SPHENOPSIDA

Equisetaceae

Equisetum hyemale L. (WSP, 19 June 1964) PNFb

SUBDIVISION PTEROPSIDA

Class Gymnospermae

Cupressaceae

Juniperus osteosperma (Torr.) Little (SN 156; JF 4, 25 July 1977) PNTbik

Ephedraceae

Ephedra viridis Coville (SN 125; JF 256, 17 May 1977) PNSbik

Pinaceae

Pinus edulis Engelm. (SN 94; JMR 389-65, 22 August 1965) PNTbik

Pseudotsuga menziesii (Mirb.) Franc (SN) PNTbk

Class Angiospermae

Subclass Dicotyledoneae

Aceraceae

Acer negundo L. (JWB NB 17, 7 June 1934; SN 264, 17 May 1973) PNTbk

Amaranthaceae

Amaranthus albus L. (JF 130, 25 June 1977) ANFi

Amaranthus leucocarpus Wats. (JF 18, 28 August 1977) AIFk

Anacardiaceae

Rhus trilobata Nutt. (SN 227, 3 July 1972) PNSbik

Toxicodendron radicans L. (MW 413) PNSb

Apocynaceae

Apocynum medium Greene (MW 431, 10 June 1935) PNFb

Asclepiadaceae

Asclepias subverticillata (Gray) Vail (SN 175, 2 July 1972; JF 62, 1 September 1977) PNFi

Funastrum heterophyllum (Engelm.) Standl (MW 221; JF 19, 28 August 1977) PNFk

Berberidaceae

Mahonia repens G. Don (SN 269, 17 May 1973; MW 459, 21 May 1935; EL, 17 April 1960; JWB E 1, 9 May 1941) PNSbk

Betulaceae

Betula occidentalis Hook. (SN 145, 1 July 1972; MW 457; WSP 3615, 19 June 1964; JWB NB 33, 17 July 1940) PNTb

Boraginaceae

Cryptantha confertiflora (Greene) Payson (JWB NB 19, 12 June 1939) PNFb

Cryptantha crassisepala (Torr. & Gray) Greene (SN) ANFb

Cryptantha flava (A. Nels.) Payson (SN 74, 9 June 1972; JF 93, 11 June 1977) PNFbk

Cryptantha jamesii (Torr.) Payson (SN 152, 1 July 1972; JF 15, 30 August 1977; JF 50, 22 July 1977) PNFbi

Cryptantha pterocarya (Torr.) Greene (SN, 3 July 1972) ANFb

Lappula occidentalis (Wats.) Greene (JF 222, 5 May 1977) AIFb

Lappula redowskii (Hornem.) Greene (SN 70, 9 June 1972; JF 189, 3 June 1977; MW G-2, 15 May 1937) AIFb

Lithospermum multiflorum Torr. (JF 40, 14 July 1977) PNFb

Cactaceae

Coryphantha vivipara (Nutt.) Britton & Rose (JF 90, 10 June 1977) PNSk

Echinocereus fendleri (Engelm.) Rumpler (JWB NB 74, 17 June 1941) PNSbik

Echinocereus triglochidiatus Engelm. (SN 325, 19 June 1973) PNSb

Opuntia erinacea Engelm. (JWB NB 78, 21 June 1941) PNSbik

Opuntia fragilis (Nutt.) Haw. (JWB H-4, 19 June 1941) PNSb

Opuntia polycantha Haw. (SN 331, 20 June 1973; JF 91, 10 July 1977) PNSbik

Opuntia whipplei Engelm. & Bigel. (JF 277, 30 June 1977) PNSi

Sclerocactus parviflorus Clover & Jotter (SN) PNSb

Sclerocactus whipplei (Engelm. & Bigel.) Britt. & Rose (JWB NB 75, 19 June 1941; SN) PNSbk

Capparidaceae

Cleome serrulata Pursh (JWB NB 21, 16 June 1939, MW I-1, 8 August 1937; JF 109, 25 June 1977) ANFbik

Caprifoliaceae

Symphoricarpos vaccinioides Rydb. (SN 310, 2 June 1973) PNSb

Caryophyllaceae

Arenaria eastwoodiae Rydb. (JF 145, 30 June 1977) PNFbik

Chenopodiaceae

Atriplex canescens (Pursh) Nutt. (MW 419, 27 June 1935; JF 203, 21 May 1977) PNSbik

Chenopodium album L. (JF 278, 13 August 1977) AIFbik

Chenopodium fremontii Wats. (MW K-1; JF 242, 30 June 1977) ANFbik

Chenopodium glaucum L. (SN 204, 3 July 1972; JF 136, 30 June 1977) AIFik

Chenopodium pratericola Rydb. (JF 160, 30 June 1977) ANFik

Kochia scoparia (L.) Schrad. (JF 115, 26 June 1977) AIFi

Salsola iberica Sennen & Pau (SN) AIFbik

Compositae (Asteraceae)

Achillea millefolium L. (SN 349, 24 July 1973) PNFbk

Ambrosia acanthicarpa Hook. (JF 25, 19 July 1977; JF 60, 1 September 1977) ANFik

Ambrosia artemisiifolia L. (JF 126, 25 June 1977) ANFik

Antennaria marginata Greene (JF 39, 14 July 1977) PNFb

Antennaria neglecta Greene (SN 150, 1 July 1972) PNFb

Antennaria parvifolia Nutt. (SN 120; JWB NB 58) PNFb

Artemisia campestris L. (JF 239, 16 June 1977) PNFb

Artemisia dracunculus L. (JWB NB 37, 17 July 1940; JF 103, 25 June 1977) PNFbik

Artemisia frigida Willd. (SN 359, 24 July 1973; JF 202, 21 May 1977; MW 451) PNSbik

Artemisia ludoviciana Nutt. (JF 87, 13 July 1977; JF 107, 25 June 1977) PNFbik

Artemisia nova A. Nels. (JF 279, 25 August 1977) PNSbk

Artemisia pacifica Nutt. (JF 3, 16 August 1977) PNFb

Artemisia tridentata Nutt. (MW 451; SN 360, 24 July 1973) PNSbk

Aster arenosus (Heller) Blake (JF 233, 30 June 1977) PNFb

Aster hirtifolius Blake (SPB M-5, 23 June 1941; SN 316, 19 June 1973) PNFb

Brickellia californica (Torr. & Gray) Gray (JF 129, 25 June 1977; JF 151, 30 June 1977) PNSbik

Brickellia grandiflora (Hook.) Nutt. (JF 228, 30 June 1977) PNFk

Brickellia scabra (Gray) A. Nels. (JF 133, 25 June 1977) PNSbik

Chaenactis stevioides H. & A. (SN 327, 20 June 1973) ANSbik

Chrysothamnus depressus Nutt. (JF 264, 16 May 1977) PNSi

Chrysothamnus nauseosus (Pall.) Britton (JF 121, 25 June 1977) PNSik

Chrysothamnus pulchellus (Gray) Greene (JWB, 24 July 1946) PNSbik

Chrysothamnus viscidiflorus (Hook.) Nutt. (JF 263, 16 May 1977) PNSbik

Cirsium pulchellum (Greene) Woot. & Standl. (JF 174, 30 June 1977) BNFbk

Conyza canadensis (L.) Cronquist (JF 155, 30 June 1977) ANFb

Erigeron concinnus (H. & A.) Torr. & Gray (SN 313, 19 June 1973; JF 88, 13 July 1977; JF 141, 30 June 1977) PNFbk

Erigeron divergens Torr. & Gray (SN 304, 1 June 1973; JWB NB-69, 19 June 1941; JWB NB-2, 21 May 1939; JF 13, 30 August 1977) BNFbi

Erigeron flagellaris Gray (JF 24, 20 July 1977; JF 54, 22 July 1977) BNFbi

Erigeron glabellus Nutt. (SN 163, 1 July 1972) BNFb

Erigeron macranthus Nutt. MW M-7; JF 48, 14 July 1977; JF 55, 2 July 1977) PNFb

Erigeron utahensis Gray (JF 29, 1 September 1977; JF 56, 22 July 1977; JF 138, 30 June 1977) PNFbi

Gaillardia pinnatifida Torr. (SN 97, 10 June 1972) PNFb

Haplopappus nuttallii Torr. & Gray (SN 137; MW 919-3157, 2 September 1938; JWB M-10; 23 June 1941) PNFbik

Haplopappus scopulorum (Jones) Blake (JF 12, 30 August 1977; JF 152, 30 June 1977) PNFbi

Heterotheca villosa (Pursh) Shinners (SN 177, 2 July 1972; JF 33, 1 September 1977; JF 68, 25 July 1977; JF 108, 25 June 1977) PNFbik

Hymenopappus filifolius Hook. (SN 78, 9 June 1972; JF 44, 7 July 1977; JF 86, 13 July 1977; JF 89, 11 June 1977) PNFbk

Hymenopappus lugens Greene (JWB M-11, 17 June 1941) PNFb

Hymenoxys acaulis (Pursh) K. F. Parker (JWB NB 23, 12 June 1939; JF 45, 7 July 1977) PNFb

Hymenoxys bigelovii (Gray) K. F. Parker (SN 301, 1 June 1973; JF 83, 13 June 1977) PNFb

Hymenoxys ivesiana (Greene) Parker (JWB NB 23, 12 June 1939) PNFb

Hymenoxys richardsonii (Hook.) Cockerell (JF 235, 13 June 1977) PNFb

Lactuca pulchella (Pursh) DC. (SN 348, 22 July 1973; JWB M-12, 28 July 1940; JF 6, 25 July 1977) PNFbk

Machaeranthera grindelioides (Nutt.) Shinners (SN 137; MW; JF 143, 30 June 1977) PNFbk

Machaeranthera hansonii Nels. (JF 11, 30 August 1977) PNFi

Machaeranthera linearis Greene (JMR 343 65, 21 August 1965)PNFbk

Machaeranthera tephrodes (Gray) Greene (JF 240, 30 June 1977) BNFb

- *Malacothrix sonchioides* (Nutt.) Torr. & Gray (SN) ANFbi
- *Psilostrophe sparsiflora* (Gray) A. Nels. (SN 161, 1 July 1972; JF 114, 26 June 1977; MW M-13; JF 139, 30 June 1977) PNFb
- *Senecio longilobatus* Benth. (JF 67, 1 September 1977; JF 95, 11 June 1977) PNFbi
- *Senecio multilobatus* Torr. & Gray (JWB NB 70, 19 June 1941; JF 186, 3 June 1977) PNFbk
- *Senecio uintahensis* (A. Nels.) Greene (SN 100, 10 June 1972) PNFb
- *Solidago canadensis* L. (SN 172, 1 July 1972) PNFb
- *Solidago occidentalis* (Nutt.) Torr. & Gray (SN 350, 24 July 1973) PNFb
- *Stephanomeria exigua* Nutt. (JMR 345-65, 21 August 1965; SN, 3 July 1972; JF 105, 25 June 1977) ANFb
- *Stephanomeria tenuifolia* (Torr.) Hall (JDB 2502, 3 August 1977) PNFb
- *Stephanomeria thurberi* Gray (JF 53, 22 July 1977) PNFb
- *Taraxacum officinale* Weber (SN 273, 17 May 1973) PIFb
- *Tetradymia canescens* DC. (SN 358, 24 July 1973; JF 161, 30 June 1977) PNSbik
- *Townsendia incana* Nutt. (JWB M-16, 18 June 1941; SN 62, 9 June 1972; JF 206, 21 May 1977) PNFb
- *Verbesina encelioides* (Cav.) Benth. & Hook. (JF 1, 1 September 1977) ANFi
- *Xanthocephalum lucida* (Greene) Shinners (JWB NB-30, 3 August 1940) PNSb
- *Xanthocephalum sarothrae* (Pursh) Shinners (MW M-9, 2 September 1937; SN 157, 11 June 1972; JF 255, 17 May 1977) PNSbik

Cornaceae

- *Cornus stolonifera* Michx. (JWB NB 39, August 1940; MW 41, May 1935; SN 308, 2 June 1973) PNSb

Crassulaceae

- *Sedum stenopetalum* Pursh (JWB NB 54, 28 May 1941) PNFb

Cruciferae (Brassicaceae)

- *Arabis perannans* S. Wats. (JWB NB 46, 19 April 1941; JF 220, 5 May 1977) PNFbi
- *Arabis pulchra* Jones (EL, 17 April 1960) PNFb
- *Descurainia pinnata* (Walt.) Britton (JWB P-4, 23 June 1941; JF 156, 30 June 1977) ANFbk
- *Descurainia sophia* (L.) Webb. (EL, 17 April 1960; SN 73, 9 June 1972) AIFbik
- *Erysimum asperum* DC. (JWB NB 52, 30 May 1941; JWB NB 7, 11 April 1939; SN 286, 21 May 1973; JF 225, 5 May 1977) PNFbk
- *Lepidium montanum* Nutt. (SN 195, 3 July 1972; JF 63, 1 September 1977) PNFbik
- *Lesquerella ludoviciana* (Nutt.) S. Wats. (JWB NB 8, 20 May 1936; SN 303, 1 June 1973) PNFb
- *Lesquerella rectipes* Woot. & Standl. (JF 184, 3 June 1977) PNFb
- *Sisymbrium altissimum* L. (JR 389-65, 22 August 1965; JF 158, 30 June 1977) AIFbk
- *Streptanthella longirostris* (S. Wats.) Rydb. (SN) ANFbik
- *Streptanthus cordatus* Nutt. ex Torr. & Gray (SN 75, 9 June 1972; JWB NB 34, 17 July 1940; JWB NB 59, 20 April 1941; EL, 17 April 1960; JF 135, 30 June 1977) PNFb
- *Thelypodium integrifolium* (Nutt.) Endl. (JF 2, 24 July 1977) BNFk
- *Thlaspi fendleri* Gray (SN; JWB NB 47, 19 April 1941) PNFb

Elaeagnaceae

- *Elaeagnus angustifolia* L. (JF 106, 25 June 1977) PITi
- *Shepherdia rotundifolia* Parry (SN 281, 17 May 1973; JF 217, 5 May 1977) PNSbik

Ericaceae

- *Arctostaphylos pungens* H. B. K. (MW 109) PNSb

Euphorbiaceae

- *Euphorbia lurida* Engelm. (JWB NB 56, 28 May 1941) PNFb
- *Euphorbia micromera* Boiss. (JF 26, 19 July 1977) ANFi

Fagaceae

- *Quercus gambelii* Nutt. (SN 160, 1 July 1972; JF 214, 21 May 1977; JWB NB 40, 17 July 1940) PNTbk
- *Quercus turbinella* Greene (JF 27, 1 September 1977) PNSi

Fumariaceae

- *Corydalis aurea* Willd. (SN 201) ANFb

Geraniaceae

- *Erodium cicutarium* (L.) L'Her (SN 252, 8 May 1973) AIFbik
- *Geranium atropurpureum* Heller (SN 116, 10 June 1972; JWB NB 28, 25 July 1940; JWB NB 42, 17 July 1940; JF 75, 12 July 1977) PNFb

Hydrophyllaceae

Phacelia corrugata A. Nels. (SN 245, 8 May 1973)	ANFb
Phacelia ivesiana Torr. (JWB 1080-1723a, 23 June 1941)	ANFbik
Labiatae (Lamiaceae)	
Moldovica parviflora (Nutt.) Britt. & Brown (SN 218, 3 July 1973)	BNFb
Leguminosae (Fabaceae)	
Astragalus amphioxys Gray (SN)	PNFb
Astragalus ceramicus Sheld. (SN 103, 10 June 1972; JWB NB 10, 11 May 1939; JF 81, 16 June 1977)	PNFb
Astragalus lentiginosus Dougl. ex Hook. (SN 251, 8 May 1973; JF 70, 20 July 1977; JF 132, 25 June 1977)	PNFbik
Astragalus mollissimus Torr. var. thompsonae (Wats.) Barneby (SN 101, 10 June 1972; JF 84, 13 June 1977)	PNFb
Astragalus sesquiflorus S. Wats. (EL, 17 April 1960; SN 276, 17 May 1973)	PNFb
Astragalus zionis Jones (JF 317, 27 July 1977; JF 178, 5 May 1977)	PNFbik
Lathyrus arizonicus Britton (JF 261, 17 May 1977)	PNFb
Lathyrus brachycalyx Rydb. (SN 111, 10 May 1972; JF 211, 21 May 1977; JWB X-3, 11 May 1941)	PNFb
Lupinus argenteus Pursh (JF 35, 27 July 1977)	PNFb
Medicago sativa L. (SN 105, 10 June 1972)	PIFb
Melilotus alba Descr. (JF 57, 22 July 1977)	BIFb
Melilotus officinalis (L.) Lam. (JF 58, 22 July 1977)	BIFb
Linaceae	
Linum aristatum Engelm. ex Wisliz. (MW Z-1, 13 August 1937; SN; JF 30, 1 September 1977)	ANFi
Linum perenne L. (MW 65, 27 May 1935)	PNFb
Loasaceae	
Mentzelia albicaulis Dougl. (JWB NB 5, 11 May 1939; SN 338, 29 June 1973)	ANFb
Loranthaceae	
Arceuthobium campylopodium Engelm. (MW AB-1, 23 August 1937)	PNFb
Phoradendron juniperinum Engelm. (SN 198)	PNFb
Malvaceae	
Sidalcea neomexicana Gray (SN)	PNFb
Sphaeralcea coccinea (Nutt.) Rydb. (SN 335, 29 June 1973; JF 71, 20 July 1977; JF 85, 13 June 1977)	PNFbik
Sphaeralcea parvifolia A. Nels. (JWB NB 72, 19 June 1941; SN 68, 2 June 1972; JF 248, 16 May 1977)	PNFbik
Nyctaginaceae	
Abronia elliptica A. Nels. (JWB NB 51, 27 May 1941; JF 187, 3 June 1977)	PNFbik
Abronia fragrans Nutt. ex Hook. (SN)	PNFb
Allionia incarnata L. (JF 65, 1 September 1977)	PNFi
Allionia linearis Pursh (JWB NB 20, 12 June 1939)	PNFb
Mirabilis comatus Standl. (SN 361, 24 July 1973)	PNFk
Mirabilis multiflora (Torr.) Gray ex Torr. (SN 174, 2 July 1972; JF 21, 20 July 1977; JF 112, 25 June 1977)	PNFi
Mirabilis oxybaphoides Gray (JF 34, 27 July 1977)	PNFk
Oxybaphus linearis (Pursh) Robins (JWB NB 20)	PNFb
Tripterocalyx wootonii Standl. (JMR 385-65, 22 August 1965; JWB NB 67, 19 May 1941; JF 31, 1 September 1977)	ANFbi
Oleaceae	
Fraxinus anomala Torr. (MW 297)	PNTi
Onagraceae	
Epilobium hornemanii Reichenb. (JF 74, 24 July 1297)	PNFk
Oenothera albicaulis Pursh (SN 106, 10 June 1972)	ANFbi
Oenothera caespitosa Nutt. (SN 194; JF 92, 10 June 1977)	PNFbik
Oenothera hookeri Torr. & Gray. (JWB, 1941)	BNFb
Oenothera longissima Rydb. (JF 43, 12 July 1977)	BNFb
Oenothera pallida Lindl. (JR 398-65, 22 August 1965; SN 217, 3 July 1972; JF 207, 21 May 1977)	PNFi
Plantaginaceae	
Plantago purshii Roem. & Schult. (SN 333, 27 June 1973)	PNFb
Polemoniaceae	
Gilia aggregata (Pursh) Spreng. (SN 58, 9 June 1972; JF 41, 18 July 1977)	PNFbik
Gilia leptomeria Gray (SN 283, 17 May 1973)	ANFbik
Gilia longiflora (Torr.) G. Don. (JMR 341-65, 21 August 1965; JF 10, 30 August 1977; JF 4, 16 August 1977)	ANFbi
Gilia scopulorum Jones (SN)	ANFb
Gilia subnuda Torr. ex Gray	

(SN)	BNFb
Leptodactylon pungens (Torr.) Nutt. (SN 126, 10 June 1972; JF 146, 30 June 1977)	PNSbk
Phlox austromontana Coville (JF 262, 16 May 1977)	PNFb
Phlox longifolia Nutt. (SN)	PNFbk
Polygonaceae	
Eriogonum alatum Torr. in Sitgr. (SN 197, 3 July 1972; JF 46, 7 July 1977)	PNFb
Eriogonum cernuum Nutt. (SN 235, 20 July 1972)	ANFb
Eriogonum corymbosum Benth. in DC (JF 281, 1 September)	PNSi
Eriogonum microthecum Nutt. (EJ, 16 August 1961; JMR 338-65, 21 August 1965; SN 239, 24 July 1972; JF 244, 8 May 1977)	PNSb
Eriogonum umbellatum Torr. (JWB NB 35, 17 July 1940; JMR 334-65, 21 August 1965; JF 32, 1 September 1977)	PNSi
Eriogonum umbellatum Torr. var. *cognatum* Greene (JF 280, 1 September 1977)	PNFb
Portulacaceae	
Portulaca oleracea L. (JF 14, 30 August 1977; JF 69, 20 July 1977)	AIFi
Portulaca retusa Engelm. (JF 73, 27 July 1977)	AIFk
Talinum brevifolium Torr. (SN 173, 2 July 1972; JF 16, 30 August 1977)	PNFi
Primulaceae	
Androsace septentrionalis L. (JF 47, 14 July 1977)	ANFb
Ranunculaceae	
Aquilegia micrantha Eastw. (JWB NAV-B-101-47, 17 June 1947; JWB NB 31, 14 July 1940; SN 93, 10 June 1972)	PNFb
Clematis ligusticifolia Nutt. (SN 229, 3 July 1972)	PNVb
Delphinium amabile Tidestr. (SN)	PNFb
Delphinium nelsonii Greene (JWB 1080-1704, 27 May 1941; JWB NB 6, 11 May 1939; SN 302, 1 June 1973)	PNFb
Delphinium scaposum Greene (JWB Am-4, 17 June 1941)	PNFb
Ranunculus cymbalaria Pursh (JF 111, 25 June 1977; JF 125, 25 June 1977; MW AM-5)	PNFi
Thalictrum fendleri Engelm. (JWB NB 44, 2 September 1940; JWB NAV-B-101-47, 17 June 1947)	PNFb
Rosaceae	
Amelanchier utahensis Koehne (SN 129, 10 June 1972; JF 213, 21 May 1977; SPB NB 62, 18 June 1941)	PNSb
Cercocarpus intricatus S. Wats. (SN 261, 17 May 1973; JWB NB 63, 12 May 1941; MW 452, JF 218, 5 May 1977)	PNSbik
Cowania mexicana D. Don. (SN 65)	PNSb
Fallugia paradoxa (D. Don.) Endl. (JF 64, 1 September 1977)	PNSi
Holodiscus dumosus (Nutt.) Heller (MW 919-3044; JWB 1080-1709, June 1942; MW 434)	PNSb
Prunus emarginata (Dougl.) D. Dietr. (SN 288, 24 May 1973; JF 163, 30 June 1977)	PNTk
Prunus virginiana L. (SN 309, 2 June 1973)	PNTb
Purshia tridentata (Pursh) DC. (SN 307, 1 June 1973)	PNSbk
Rosa woodsii Lindl. (SN 113, 10 June 1972; JWB NB 16, 7 June 1939; JF 157, 30 June 1977)	PNSb
Rubiaceae	
Galium aparine L. (JF 166, 30 June 1977)	ANFk
Galium triflorum Michx. (SN 154, 1 July 1972)	PNFb
Kelloggia galioides Torr. (JF 241, 3 June 1977)	PNFbk
Salicaeae	
Populus angustifolia James (JF 281, 30 June 1977)	PNTi
Populus fremontii S. Wats. (SN 179)	PNTbi
Populus tremuloides Michx. (SN 171)	PNTb
Salix exigua Nutt. (SN 181, 2 July 1972)	PNSbi
Salix goodingii Ball (SN; JF 128, 25 June 1977)	PNSbk
Salix lasiolepis Benth. (JF 208, 21 May 1977)	PNTb
Santalaceae	
Comandra pallida DC. (JF 149, 30 June 1977; JF 196, 31 May 1977)	PNFbk
Saxifragaceae	
Fendlera rupicola Gray (SN 289, 24 May 1973; JF 212, 21 May 1977)	PNSbik
Heuchera parvifolia Nutt. (SN 118, 10 June 1972)	PNFb
Heuchera rubescens Torr. (SN 311, 19 June 1973)	PNFb
Ribes cereum Dougl. (JF 142, 30 June 1977; JF 204, 21 May 1977)	PNSbk
Ribes leptanthum Gray (JF 169, 30 June 1977; JF 205, 21 May 1977)	PNSk
Ribes viscossissimum Pursh (SN	

290, 24 May 1973)	PNSk
Scrophulariaceae	
Castilleja linarifolia Benth. (SN 96, 10 June 1972; JF 49, 22 July 1977; JF 134, 30 June 1977)	PNFbik
Cordylanthus wrightii Gray (JMR 340-65, 21 August 1965; EJ, 16 August 1961)	ANFb
Mimulus eastwoodiae Rydb. (SN 221; JF 20, 20 July 1977; JF 165, 30 June 1977)	PNFbk
Penstemon ambiguus Torr. (EL; SN; JF 230, 18 May 1977)	PNSb
Penstemon barbatus (Cav.) Roth (JF 59, 22 July 1977)	PNFb
Penstemon comarrhenus Gray (JWB 27 June 1947; JF 162, 30 June 1977)	PNFb
Penstemon Eatoni Gray (SN 108, 10 June 1972; JDB 2503, 3 August 1974)	PNFb
Penstemon virgatus Gray (JF 52, 12 July 1977)	PNFb
Solanaceae	
Chamaesarcha coronopus (Dunal) Gray (SN 183, 2 July 1972)	PNFi
Datura meteloides DC. (JF 282, 30 June 1977)	ANFbik
Lycium pallidum Miers. (SN; JF 98, 26 June 1977)	PNSi
Nicotiana attenuata Torr. (JMR 400-65, 22 August 1975)	PNFi
Physalis fendleri Gray (SN 158, 1 July 1972; JF 137, 30 June 1977)	PNFbi
Physalis hederaefolia Gray (JF 153, 30 June 1977)	PNFk
Solanum jamesii Torr. (JF 17, 28 August 1977)	PNFk
Tamaricaceae	
Tamarix ramosissima Ledels. (JF 283, 30 June 1977)	PISi
Umbelliferae (Apiaceae)	
Cymopterus newberryi (S. Wats.) M. E. Jones (JWB, 16 May 1941)	PNFb
Urticaceae	
Parietaria pennsylvanica Muhl. (JF 123, 25 June 1977)	ANFi
Verbenaceae	
Verbene bracteata Lag. & Rodr. (SN 337, 29 June 1973)	PNFb
Subclass Monocotyledoneae	
Commelinaceae	
Tradescantia occidentalis (Britt.) Smyth (SN 151; JF 80, 16 June 1977; JWB NB 22, 12 June 1939; JMR 335-65, 22 August 1965)	PNFbik
Cyperaceae	
Carex occidentalis Bailey (JF 51, 12 July 1977; JF 173, 16 June 1977)	PNGb
Carex rossii Boott (JF 172, 16 June 1977)	PNGlb
Eleocharis macrostachya Britton (JF 28, 1 September 1977; JF 119, 25 June 1977)	PNGLbi
Gramineae (Poaceae)	
Agropyron caninum (L.) Beauv. (SN 85, 10 June 1972; JF 182, 3 June 1977)	PNGbk
Agrostis exarata Trin. (SN 182, 2 July 1972)	PNGi
Agrostis semiverticillata (Forsk.) Christ. (SN 356, 24 July 1973; JF 38, 27 July 1977; JF 118, 25 June 1977)	PIGk
Alopecurus aequalis Sobol. (SN 354, 24 July 1973)	PNGk
Andropogon hallii Hack. (JF 66, 1 September 1977)	PNGi
Aristida arizonica Vasey (SN 188, 2 July 1973)	PNGb
Aristida fendleriana Steud. (JF 100, 25 June 1977; JF 117, 25 June 1977)	PNGbi
Bouteloua barbata Lag. (JF 72, 1 September 1977)	ANGi
Bouteloua curtipendula (Michx.) Torr. (SN 347, 29 June 1973)	PNGi
Bouteloua gracilis (H.B.K.) Lag. (JF 284, 30 June 1977)	PNGb
Bromus carinatus Hook. & Arn. (SN 224, 3 July 1972)	PNGbk
Bromus ciliatus L. (SN 84, 10 June 1972; JF 181, 3 June 1977)	PNGb
Bromus marginatus Nees (JF 168, 30 June 1977)	PNGb
Bromus rubens L. (JF 104, 25 June 1977)	AIGik
Bromus tectorum L. (SN 207, 3 July 1973; JF 192, 3 June 1977)	AIGbik
Elymus glaucus Buckl. (JF 42, 18 July 1977)	PNGb
Glyceria striata (Lam.) Hitch. (JF 7, 25 July 1977)	PNGb
Hordeum Leporinum Link (SN)	ANGb
Lycurus phleoides H.K.B. (JF 23, 20 July 1977)	PNGi
Muhlenbergia andina (Nutt.) A. S. Hitchc. (JF 8, 1 September 1977)	PNGb
Muhlenbergia curtifolia Scribn. (JMR 332-65, 21 August 1965)	PNGi
Muhlenbergia pungens Thurb. (JMR 342-65, 21 August 1965; SN 243, 27 July 1972)	PNGb
Muhlenbergia thurberi Rydb. (JF 120, 25 June 1977)	PNGbi
Munroa squarrosa (Nutt.) Torr. (SN; JF 9, 30 August 1977; JF 61, 1 September 1977)	ANGi
Oryzopsis Hymenoides (R. & S.) Riker (SN 343, 29 June 1973)	PNGbik

Oryzopsis micrantha (Trin. & Rupr.) Thurb. (SN 86, 10 June 1972; JF 179, 3 June 1977)	PNGb
Poa fendleriana Vasey (MW 7; MW 28; SN 275, 17 May 1973)	PNGbk
Poa longiligula Scribn. & Williams (SN; MW 14; JF 94, 13 June 1977; JF 99, 25 June 1977)	PNGbik
Poa pratensis L. (SN 357, 24 July 1973; JF 167, 30 June 1977)	PIGbk
Polypogon monspeliensis (L.) Desf. (SN 351, 24 July 1973; JF 110, 25 June 1977)	AIGbik
Puccinellia airoides (Nutt.) Wats. & Coult. (JF 170, 30 June 1977)	PNGbk
Sitanion hystrix (Nutt.) J. G. Smith (SN 323, 19 June 1973; JF 82, 13 June 1977)	PNGbik
Sporobolus airoides Torr. (JF 22, 19 July 1977)	PNGik
Sporobolus cryptandrus (Torr.) Gray (JMR 344-65, 21 August 1965; SN 228, 3 July 1972; JF 96, 25 June 1977)	PNGbik
Sporobolus flexuosus (Thurb.) Rydb. (SN)	PNGb
Stipa comata Trin. & Rupr. (SN 80; JF 180, 3 June 1977)	PNGbk
Vulpia octoflora (Walt.) Rydb. (SN; JF 269, 18 May 1977)	ANGbik
Juncaceae	
Juncus balticus Willd. (JF 171, 16 June 1977)	PNGLbi
Juncaginaceae	
Triglochin maritima L. (JF 227, 26 June 1977)	PNGLi
Liliaceae	
Allium macropetalum Rydb. (JWB NB 11, 20 May 1939; SN 326, 20 June 1973)	PNFb
Calochortus nuttallii Torr. & Gray (SN 99, 10 June 1972; JWB NB 13, 10 June 1939)	PNFb
Fritillaria atropurpurea Nutt. (SN 287, 23 May 1973; MW 287, May 1930)	PNFb
Smilacina stellata (L.) Desf. (MW Y-4; SN 148, 3 July 1972; SN 223, 3 July 1972; JF 154, 30 June 1977)	PNFbk
Yucca angustissima Engelm. (SN 56, 9 June 1972; JWB NB 76, 21 June 1941)	PNSbik
Yucca baccata Torr. (SN 315, 19 June 1973)	PNSb
Orchidaceae	
Habenaria sparsiflora S. Wats. (SN 167, 1 July 1972)	PNFb
Sparganiaceae	
Sparganium eurycarpum Engelm. (JF 226, 26 June 1977)	PNGLi

Literature Cited

Allan, J. S. 1977. The plant communities of Arches National Park. Unpublished Ph.D. dissertation, Brigham Young University, Provo, Utah. 98 pp.

Brotherson, J. D. 1967. A study of certain community relationships of *Eriogonum corymbosum* Benth. *In*: DC in the Uintah Basin, Utah. Unpublished master's thesis, Brigham Young University, Provo, Utah. 100 pp.

Campbell, V. O. 1977. Certain edaphic and biotic factors affecting vegetation in the shadscale community of the Kaiparowits area. Unpublished master's thesis, Brigham Young University, Provo, Utah. 58 pp.

Cooley, M. E. 1958. Physiography of the Glen-San Juan Canyon area, Part 1. Plateau 31:21–33.

______. 1962. Late Pleistocene and Recent erosion and alluviation in parts of the Colorado River system, Arizona and Utah. *In*: Geological Survey Research 1962: short papers in geology, hydrology, and topography, articles 1–59, pp. 48–50. United States Geological Survey Professional Paper 450-B. Washington.

Dean, J. S. 1969. Chronological analysis of Tsegi phase sites in northeastern Arizona. Papers of the Lab. of Tree-ring Res. No. 3. University of Arizona Press. Tuscon, Arizona. 207 pp.

Flowers, S. 1963. The lichen and moss flora of Betatakin Canyon and vicinity, Navajo National Monument, Arizona. University of Utah Div. of Biol. Sci. Misc. Papers No. 3. 10 pp.

Gregory, H. E. 1916. The Navajo country: a geographic and hydrographic reconnaissance of parts of Arizona, New Mexico, and Utah. United States Geological Survey Watersupply paper. Washington.

______. 1917. Geology of the Navajo country: a reconnaissance of parts of Arizona, New Mexico, and Utah. United States Geological Survey Professional Paper 93. Washington.

Hack, J. T. 1942. The changing physical environment of the Hopi Indians of Arizona. Papers of the Peabody Museum of American Archaeology and Ethnology, Harvard University. Vol. 35, No. 1. Reports of the Awatovi Expedition, No. 1. Cambridge.

______. 1945. Recent geology of the Tsegi Canyon. Appendix I *in* R. L. Beals, George W. Brainerd, and Watson Smith, Archaeological Studies in Northeast Arizona. University of California Press, Berkeley and Los Angeles.

Harshbarger, J. W., C. A. Repenning, and J. H. Irwin. 1957. The stratigraphy and the uppermost Triassic and Jurassic rocks of the Navajo country. United States Geological Survey Professional Paper 291. Washington.

Harrington, H. D. 1964. Manual of the plants of Colorado. The Swallow Press, Inc. Chicago, Illinois. 666 pp.

KEARNEY, T. H., AND R. H. PEEBLES. 1960. Arizona flora. University of California Press. Berkeley, California. 1085 pp.

MCDOUGAL, W. B. 1973. Seed plants of northern Arizona. The Museum of Northern Arizona, Flagstaff, Arizona. 594 pp.

SELLERS, W. D. 1964. The climate of Arizona. Pp. 3–64. *In*: Christine R. Green and William D. Sellers, eds., Arizona Climate. University of Arizona Press, Tucson, Arizona, 175 pp.

WELSH, S. L. AND G. MOORE. 1973. Utah plants—Tracheophyta. Brigham Young University Press. Provo, Utah. 474 pp.

WOODBURY, A. M. 1963. Biological-ecological aspects of Betatakin Canyon, Navajo National Monument, Arizona. University of Utah Div. of Biol. Sci. Misc. Papers No. 2. 56 pp.

ENVIRONMENTAL INTERACTION IN SUMMER ALGAL COMMUNITIES OF UTAH LAKE[1]

Mark C. Whiting,[2] Jack D. Brotherson,[2]
and Samuel R. Rushforth[2]

Abstract.— Utah Lake is a shallow eutrophic lake in central Utah. It is characterized by high nutrient and silt loads and by large algal blooms in late summer and early fall. Phytoplankton samples and environmental data were taken from June through August 1974. Phytoplankton species were identified and then quantified in a Palmer counting cell. Environmental continuum theory was employed to describe algal succession, and regression analysis was used to discover interactions between algal communities and the environment. Phytoplankton communities in June were characterized by high species diversity. As the lake environment became stressed in late summer due to higher turbidity, nutrient levels, pH, and available inorganic carbon species diversity decreased. By August, the phytoplankton flora was composed essentially of only two species, *Ceratium hirundinella* and *Aphanizomenon flos-aquae*.

Utah Lake is a shallow eutrophic lake in central Utah (Fig. 1). It is the largest naturally occurring freshwater lake in the state, covering some 388 km^2 (Bolland 1974). Water from the lake is presently used for irrigation and water regulation as well as for recreational boating and fishing.

In the past, commercial fisheries on Utah Lake have been an important resource for the state of Utah. At the time of settlement, the fish population was dominated by a variety of Bonneville cutthroat trout (*Salmo clarki*) which was adapted to the eutrophic conditions of the lake. The trout fishery became vital to the survival of the early Mormon pioneers during the drought and crop failures from 1855 to 1858. However, with water manipulation for agriculture and the introduction of exotic fish species, the trout rapidly became extinct in subsequent years. During the depression years of 1929 through 1939 commercial fishing for introduced species, mainly carp and white bass, became an important industry and food source. Current use of Utah Lake fisheries is minimal and limited to carp, which are used for fish meal.

Utah Lake is characterized by late summer and early fall algal blooms, nutrient enrichment, high silt load, and total dissolved solids and other environmental stresses. Due to the shallowness of the lake (average depth 2.4 m), fine silt-clay sediments are often stirred up by storms, giving the lake water a characteristic gray-green color. The average summer Secchi disk reading is 24 cm, with a range of 12 to 50 cm. In addition, the lake basin receives the flow of numerous mineral springs high in carbonates and sulfates.

During late summer, when water levels are lowest, the lake approaches a slightly saline ecosystem. According to the U.S. Geological Survey (Hem 1970), lakes with 1,000-3,000 mg/liter dissolved solids can be considered to be slightly saline. Summer values for dissolved solids in Utah Lake range from 795 to 1,650 mg/l and are thus in the lower part of this range.

Previous algal studies of Utah Lake were done by Tanner (1930, 1931), Snow (1932), Harding (1970, 1971), and Bolland (1974). Tanner's pioneering works listed several of the algae prominent in the lake. Both Harding and Snow did taxonomic studies dealing with littoral and planktonic algae. Bolland's work dealt with the fossil diatom flora in the lake sediments. Bolland's research indicates that the diatom flora has not changed greatly since presettlement times.

Data for this study were gathered during

---

[1] This work was financed in part by the National Science Foundation and Brigham Young University.

[2] Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602.

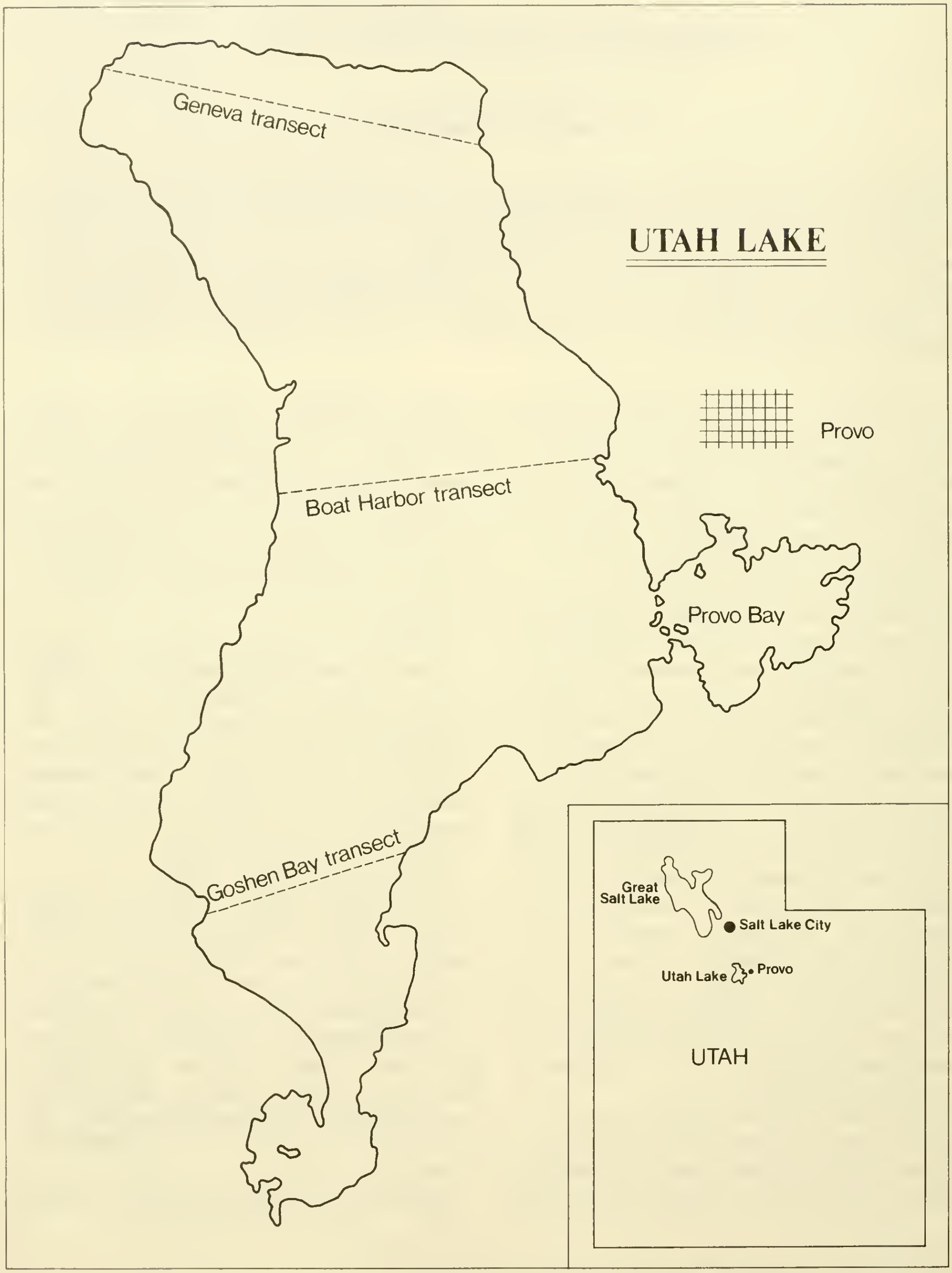

UTAH LAKE
Geneva transect
Boat Harbor transect
Goshen Bay transect
Provo
Provo Bay
Great Salt Lake
Salt Lake City
Utah Lake
Provo
UTAH

Fig. 1. Utah Lake, showing geographical position with respect to the state of Utah, Provo, and the Great Salt Lake.

the summer of 1974. There had been no previous quantitative study of the extant planktonic flora. The study resulted in a floristic paper (Rushforth et al., in press) as well as estimates of productivity and a description of the seasonal succession of summer algal species in Utah Lake to be reported herein.

Methods

Phytoplankton samples and environmental data were collected from June to August 1974. Samples were taken along three transects at nine-day intervals throughout the study period. The transects (Fig. 1) included 14 sample sites permanently marked with buoys. Transects were chosen to cross three major portions of the lake, each with possible differences in ecological conditions. The Geneva transect crossed the northern part of the lake from the outfall of the settling ponds of Geneva Works of the United States Steel Corporation to the western shore. The midlake transect ran west from the Provo Boat Harbor (near the mouth of the Provo River) to the west shore. The southern transect crossed Goshen Bay from Lincoln Beach to the west shore. The Geneva and Boat Harbor transects included five sampling sites, and the shorter Goshen transect had four sampling sites.

Phytoplankton samples were collected by pouring known volumes of lake water through a 67-μm mesh plankton net. Algae were washed from the net, collected in 30-ml vials, and immediately preserved in formalinacetic acid (FAA). The vials were later subsampled in the laboratory and individual algae were counted in Palmer counting cells (Palmer and Maloney 1954) at 400X magnification, using Zeiss RA research microscopes. Individual algae encountered were identified to the species level by two of us (Whiting and Rushforth). An "individual" for filamentous or colonial forms was considered to be a single filament or colony. Tallies were made for each species, as well as for the total number of individuals per subsample. The density of organisms in the original lake water was calculated using multiplication factors determined by the volume of filtered lake water. At least 400 individuals were counted in each sample to reduce sample variance (Clark 1956).

Selected water chemistry tests were performed in the field using a Hach DR/EL-2 Direct Reading Engineer's Lab. Tests for dissolved oxygen, free carbon dioxide, pH, and Jackson Turbidity readings were performed. In addition, a YSI conductivity meter was used to measure salinity, conductivity, and water temperature. Secchi disk readings and general meterological conditions were also recorded.

Further water chemistry tests were performed in the laboratory. Water samples were collected in opaque Nalgene bottles from approximately 25 cm below the water surface and were refrigerated until analyzed. Laboratory analyses included total alkalinity, carbonate alkalinity, total hardness, calcium hardness, magnesium hardness, nitrate, orthosphosphate, sulfate, and silica. All tests were performed within 24 hours of collection, using standard methods (Taras 1971).

Changes in phytoplankton populations through the summer were evaluated, using the continuum methods of Curtis and McIntosh (1950, 1951). Continuum theory is an approach to vegetation and its response to environmental gradients. Continuum study involves the calculation of an index number for each sample which places that sample at some point along an environmental gradient. The index number is considered to reflect the effects of the total environment on a sample expressed in terms of the species composition and their relative abundance. To demonstrate succession, the gradient herein is generated as a time continuum.

To generate the continuum index numbers used, the average density (in numbers of organisms/liter) for each species was calculated for all sites on each sample date. Adaptation numbers assigned to each algal species reflect the date at which each achieved maximum abundance. The adaptation numbers ranged from 1 to 8, corresponding to eight sample dates beginning on 13 June 1974 and ending 15 August 1974. The adaptation numbers for all species present in any one sample were then summed and averaged. The average adaptation number (continuum index number) for a sample describes its position along the time continuum. Sample index values ranged from 1.58 to 7.00. No sample was found to contain exclusively early summer species or late summer species.

All sample index values were plotted along an axis representing the time continuum. The continuum was then divided into six "natural" groups of approximately equal length, utilizing naturally occurring breaks as nearly as possible. The six divisions of the continuum allowed averages of environmental and biotic parameters to be calculated for each unit. Such average values show the successional trends along the continuum. The parameters plotted included eight major algal species, nine significant environmental parameters, environmental variation (heterogeneity), community variation, and species diversity.

A similarity index matrix using environmental data for each stand in each unit of the continuum was constructed. Mean similarity indices and standard deviation values for each unit of the continuum were then computed. A coefficient of variation was then computed from these values (Gilmartin 1974). All data values were adjusted to range from one to 10 to avoid overweighting some parameters because of their large numerical values.

Community variation was measured as above, except the data utilized were taken from the relative densities of the species present. In this instance, community variation is considered to be a measure of the evenness of the contribution each species makes to a sample.

Species diversity was calculated, using the Shannon-Wiener formula, as follows:

$$D = -\Sigma p_i \log p_i$$

The term p_i refers to the portion of the sample that each species contributes. The Shannon-Wiener formula expresses diversity in terms of the number of species present as well as the evenness of the contribution that each species makes to the total sample.

The response of individual species to single environmental parameters was assessed using the linear regression analysis. Those species with significantly similar responses ($\alpha = 0.01$) to the same environmental parameters were grouped together into "clusters."

Results

A total of 107 phytoplankton and environmental samples were taken. Ninety-five species were identified and ranked by importance values (average relative density X average percent presence). The six most important species and their importance values were: *Ceratium hirundinella* (3,303), *Aphanizomenon flos-aquae* (1,725), *Melosira granulata* (1,255), *Microcystis protocystis* (252), *Anabaena spiroides* (249), and *Anabaena flos-aquae* (154) (Fig. 2).

The early summer flora can be characterized by low standing crop (an average of 11,260 ± 25,700 organisms/liter in June) and rich species diversity. The June communities were dominated by several species of green algae, including *Ankyra judayi*, *Schroederia setigeria*, *Treubaria triappendiculata*, *Dictyosphaerium ehrenbergii*, *Pediastrum duplex*, and three varieties of *Ankistrodesmus falcatus*. Associated with these chlorophytes were the blue-greens *Anabaena flos-aquae* and *Microcystis protocystis*, the diatom *Melosira granulata*, and the dinoflagellate *Ceratium hirundinella*.

By early July, the green algae as a group began to decline in importance and were replaced by *Melosira granulata*, *Ceratium hirundinella*, and *aphanizomenon flos-aquae* (Fig. 3). King (1970) and others have indicated that the green algae tend to require free CO_2 for maximum growth and are poor competitors for bicarbonate. Our evidence seems to corroborate this conclusion. Free CO_2 in Utah Lake declined to levels that were undetectable with Hach chemistry (Fig. 4) at the same time the green algae decreased in importance. The July standing crop averaged 329,425 ± 291,410 organisms/liter, almost 30 times the June average.

August phytoplankton communities were much reduced in species diversity, often consisting only of two species, *Ceratium hirundinella* and *Aphanizomenon flos-aquae*. These two taxa were usually 10-50 times

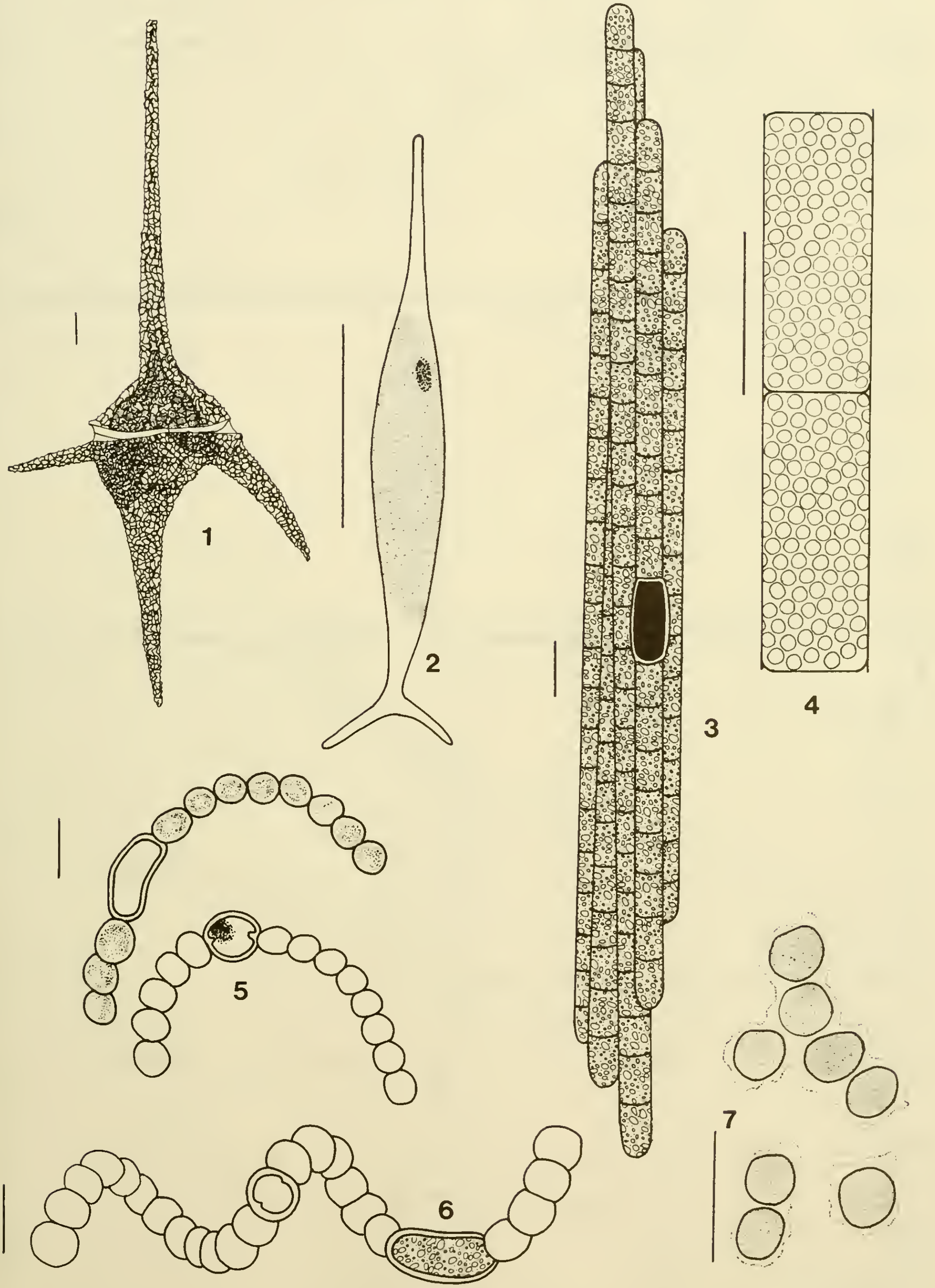


Fig. 2. Dominant phytoplankton species in the Summer Utah Lake flora. 1, *Ceratium hirundinella*; 2, *Ankyra judayi*; 3, *Aphanizomenon flos-aquae*; 4, *Melosira granulata*; 5, *Anabaena flos-aquae*; 6, *Anabaena spiroides*; 7, *Microcystis protocystis*. Each scale equals 10 μm.

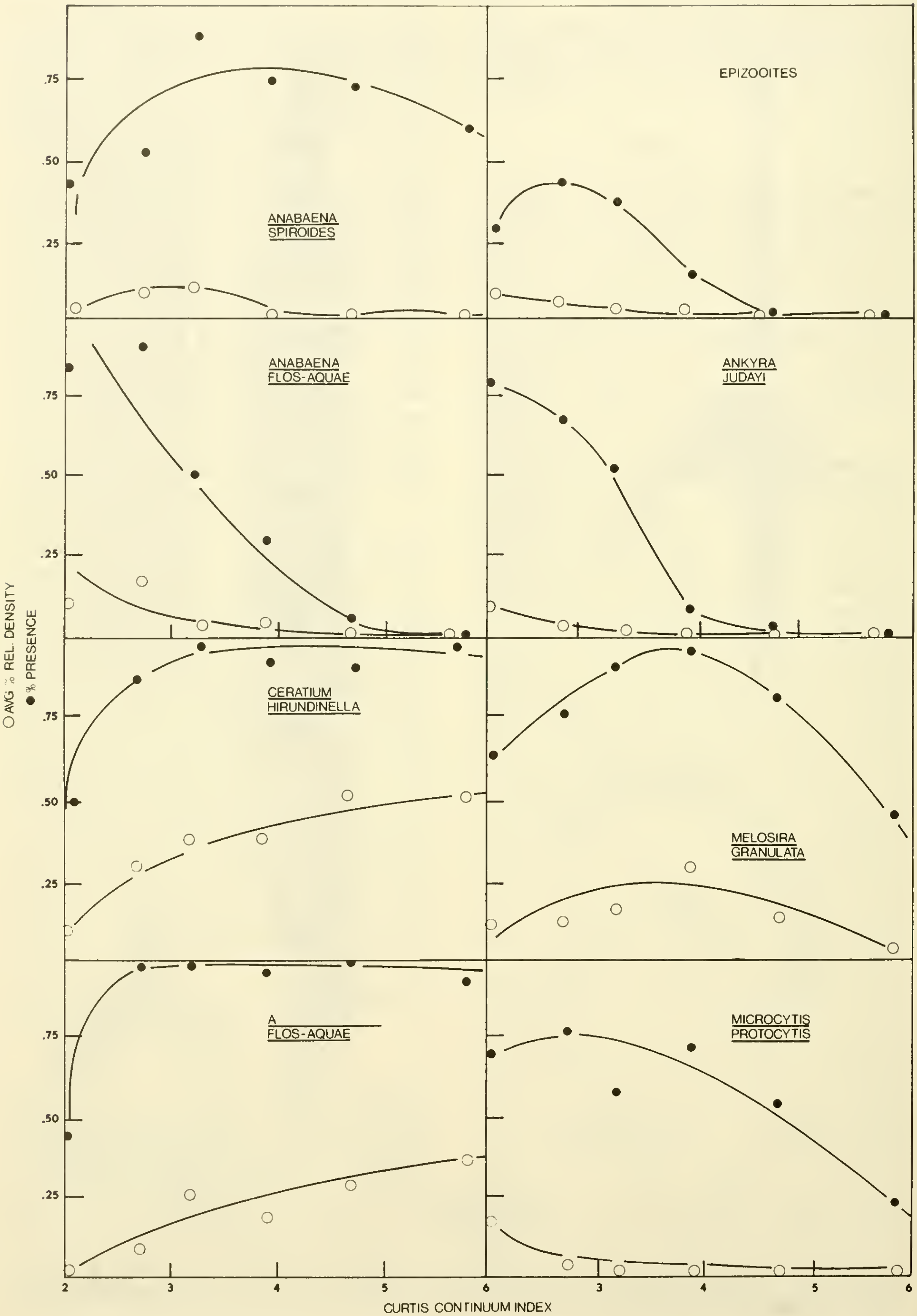


Fig. 3. Relative density and percent presence of common algal species in the Utah Lake summer 1974 flora plotted on the Curtis continuum index.

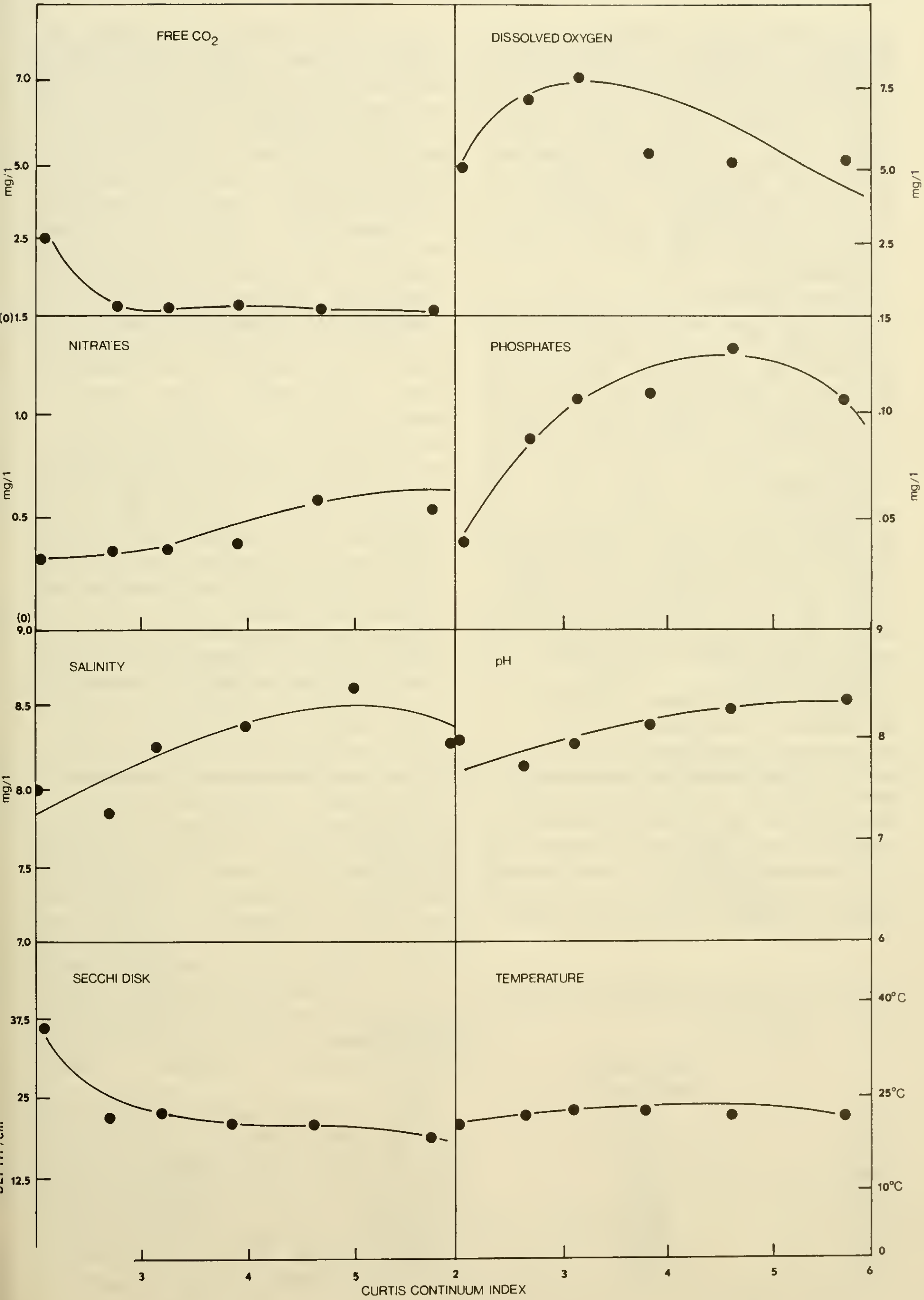


Fig. 4. Selected environmental gradients in Utah Lake in the summer of 1974, plotted on the Curtis continuum index.

more abundant than any other species. The decline in other species, especially *Melosira granulata*, might be attributed to any of a number of factors, such as decrease in availability of inorganic carbon, higher turbidity, higher salinity, or interspecific competition. The average estimate of the August standing crop was 5,405,226 ± 15,719,846 organisms/liter, almost 16 times the average for July and nearly 500 times the average for June (Table 1).

Biomass estimations for any given day showed large variation from one sample site to the next. This disjunct distribution was probably due to currents and possibly patchiness of the environment. George and Edwards (1973) have shown that zooplankton distribution is strongly correlated with Langmuir circulations. They demonstrated that *Daphnia* tend to aggregate in upwellings between foam lines. Presumably, phytoplankton may also be oriented in relation to Langmuir currents. Floating objects, such as blue-green algae with gas vacuoles, should aggregate in the foam lines. Other algae with well developed powers of locomotion might aggregate between foam lines as do zooplankton.

Analysis of phytoplankton using the Curtis continuum is summarized in Fig. 3. The six species with the highest importance values are plotted against the continuum. *Ankyra judayi* and "epizooites" (two unidentified species of Chrysophyta found on copepods) were also plotted. Although not very important overall, they were included because of their importance in the early summer. Generally, the continuum data indicate similar trends to those already described. The early summer phytoplankton consisted of a diverse group of diatoms, and green and blue-green algae. Although present from the beginning of the study, *Aphanizomenon*, *Ceratium*, and *Melosira* did not become abundant until July. *Melosira* showed its maximum growth around mid-July. *Aphanizomenon* and *Ceratium* continued to become more abundant until the end of the study in August, when they made up approximately 90 percent of the total flora.

TABLE 1. Mean standing crop values of Utah Lake algae in the summer of 1974 according to collection date.

Date	Mean number of organisms per liter
4 June	13,758
13 June	2,230
21 June	20,754
3 July	52,251
10 July	416,128
18 July	541,128
27 July	344,968
7 Aug.	724,061
15 Aug.	10,866,586

Analysis of environmental parameters using the Curtis continuum is summarized in Figure 4. Generally, the lake became a more stressful system as the season progressed. Availability of inorganic carbon for photosynthesis decreased through the summer to limiting levels (King 1970). Water transparency decreased dramatically in early July and decreased more slowly till the end of the study. Phosphates and nitrates showed maximums in late July, then decreased slightly in August. Temperature and pH increases were slight.

Environmental stresses on the phytoplankton in the late summer had the effect of reducing biological and environmental diversity. Figure 5 summarizes diversity trends along the time continuum. Environmental variation decreased through the summer, essentially reducing the number of niches available to organisms. Species diversity (measured by the Shannon-Wiener index) and community variation (the evenness of the contribution made by each species) also decreased through the summer. The last point on the community variation curve is much higher than the overall trend, due to the fact that in August the algal communities were composed of approximately equal contributions of *Ceratium* and/or *Aphanizomenon*, which normally comprised over 90 percent of the algae in a given sample.

Simple regression analysis of individual species plotted against environmental gradients shows several significant relationships (Table 2). Species showing the same significant trends were grouped into units. The first two groups are essentially early summer species and are predominately green and blue-green algae. As expected, they generally correlate with environmental parameters that predominate in the early summer, such as high light penetration, free CO_2, and low water temperatures. *Aphanizomenon* and *Ceratium* correlate with environmental parameters that were prevalent in the latter part of the season (i.e., high turbidity, high salinity, high phosphates, basic pH, and higher temperatures). As mentioned previously, increase in temperature through the season was slight and, therefore, is probably not a causal relationship even though the correlation with *Aphanizomenon* and *Ceratium* was significant.

DISCUSSION

Communities seldom appear as discrete units. In many cases closely allied communities intergrade one with another both in time and space and often exhibit no distinct boundaries between them. This is especially true of aquatic systems and in instances of biological succession. Therefore, the continuum theory as used in this paper is especially useful in the description of the algal communities of Utah Lake. The Curtis continuum has been traditionally used to describe the response of terrestrial vegetation to environmental gradients. However, the principle is just as applicable to aquatic systems where the species involved are mobile and succession is seasonal.

The Curtis continuum is also especially useful in environments that are highly fluid, as in the case of planktonic systems. Thus, we have noted in Utah Lake that certain geographical regions maintain early summer floras for more extended periods of time due to local environmental conditions which approximate earlier seasonal conditions. This was noted particularly in the Provo Boat Harbor and Goshen Bay, where spring and river influences are prominent.

Summer phytoplankton communities in Utah Lake are marked by decreases in diversity of the flora as the system becomes more stressed and/or uniform. The phytoplankton of June are a diverse assortment of species representing several algal divisions. Chlorophyta are important and are mainly associated with Cyanophyta and diatoms. The July phytoplankton are still a diverse group, but are predominately *Melosira granulata*, two species of *Anabaena*, and *Ceratium hirundinella*. The reduction of species

TABLE 2. Species correlation patterns with respect to environmental parameters as analyzed by regression analysis. Species with similar responses are grouped. All correlations listed are at the 0.01 significance level.

Species Clusters	Correlations Positive	Negative
Ankistrodesmus falcatus var. mirabilis Ankistrodesmus falcatus var. stipatus Dinobryon divergens Merismopedia glauca Holopedium irregulare Trebaria triappendiculata	Light penetration Free CO_2	Dissolved O_2 Conductivity Total alkalinity SiO_2
Anabaena flos-aquae Ankyra judayi Epizooites Microcystis incerta Pediastrum duplex Chlamydomonas globosa	Total alkalinity Calcium hardness	Water temperature Total hardness
Carteria stellifera Scenedesmus quadracauda	Total hardness	Nitrates Magnesium hardness
Aphanizomenon flos-aquae Ceratium hirundinella	Turbidity Salinity Phosphates pH Water temperature	

diversity to an almost exclusive *Aphanizomenon-Ceratium* community by August is probably due to competition, release of allelopathic substances by *Aphanizomenon* (Palmer 1962), and reduction of environmental niches due to decreased variability in the envirionment (Fig. 5).

Silica depletion to less than 0.5 mg/liter has been implicated as a factor that is often important in determining succession from diatom-dominated communities to blue-greens (Lund 1965). However, this is not the case in Utah Lake, where silica levels are very high (an average of 19.4 mg/liter for the summer and even higher in August).

Water temperature has been shown to be very important in influencing succession from diatom-dominated to blue-green-dominated floras (Patrick 1969). Apparently, this is not the case in Utah Lake. Water temperature is relatively constant throughout the study period and is highest in July when *Melosira* (the dominant diatom) is most abundant.

King (1970) has shown that, under conditions of low alkalinity and high pH, algae may be carbon limited. Blue-green algae seem to be most tolerant to these conditions and Chlorophyta seems to be most sensitive. In Utah Lake, there was a continuing decrease in available inorganic carbon (Fig. 6). The disappearance of most chlorophytes corresponds with the period of greatest decrease in carbon availability. In August, when most of the remaining algal species were replaced by *Aphanizomenon* and *Ceratium*, carbon stress was most severe. Many samples had a pH of 8.5 or more and carbonate alkalinity near 20 mg/liter. King's data (1970) indicate that these conditions are marginal for growth of assorted blue-greens used in his cultures. From this information, carbon limitation is probably an important factor in determining the composition of the summer phytoplankton communities in Utah Lake.

It is important to note that August communities in the Lake were dominated by *Aphanizomenon flos-aquae* and *Ceratium hirundinella*, which comprised between 89 and 100 percent of the total algal standing crop. These communities were often composed of only *Aphanizomenon* or *Ceratium* exclusively. We believe this is strong evidence that competitive exclusion is an important factor in regulating the late summer communities of Utah Lake. This hypothesis is presently under investigation in our laboratory.

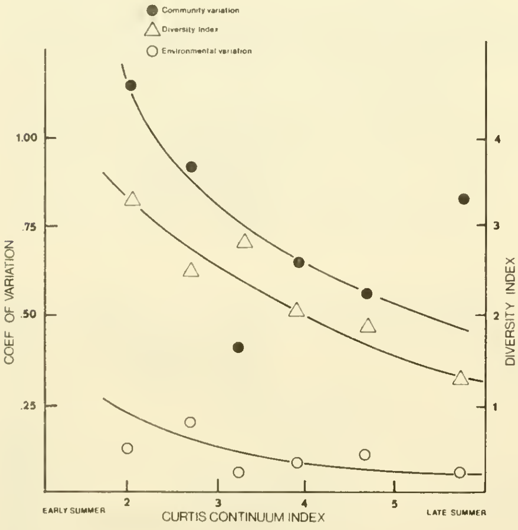


Fig. 5. Trends in species diversity, community variation, and environmental variation in Utah Lake in the summer of 1974, plotted on the Curtis continuum index.

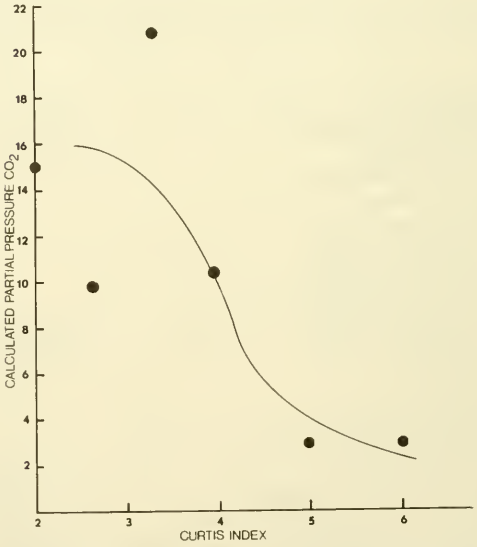


Fig. 6. Partial pressure of CO_2 in Utah Lake in the summer of 1974, calculated from disassociation constants plotted on the Curtis continuum index.

LITERATURE CITED

BOLLAND, R. F. 1974. Paleoecological interpretation of the diatom succession in recent sediments of Utah Lake, Utah. Unpublished doctoral dissertation, University of Utah, Salt Lake City.

CLARK, W. J. 1956. An evaluation of methods of concentrating and counting phytoplankton of Bear Lake, Utah-Idaho. Unpublished master's thesis, Utah State University, Logan.

CURTIS, J. T., AND R. P. MCINTOSH. 1950. The interrelations of certain analytic and synthetic phytosociological characters. Ecology 31:434–455.

______. 1951. An upland forest continuum in the prairie-forest border region of Wisconsin. Ecology 32:476–496.

GEORGE, D. G., AND R. W. EDWARDS. 1973. *Daphnia* distributions with Langmuir circulations. Limnology and Oceanography 18:789–800.

GILMARTIN, A. J. 1974. Variation within populations and classification. Taxon 23(4):523–536.

HARDING, W. J. 1970. A preliminary report on the algal species presently found in Utah Lake. Great Basin Nat. 30(2):99–105.

______. 1971. The algae of Utah Lake. Part 2. Great Basin Nat. 31(3):125–134.

HEM, J. D. 1970. Study and interpretation of the chemical characteristics of natural waters. 2d ed. Geological Survey Water Supply Paper 1473, U.S. Government Printing Office, Washington, D.C.

KING, D. L. 1970. The role of carbon in eutrophication. Journal of Water Pollution Control Federation 42(12):2035–2051.

LUND, J. W. G. 1965. The ecology of the freshwater phytoplankton. Biological Review 40:231–293.

PALMER, C. M. 1962. Algae in water supplies. U.S. Department of Health, Education, and Welfare, Amer. Pub. Health Service Pub. 657.

PALMER, C. M., AND T. E. MALONEY. 1954. A new counting slide for nannoplankton. American Society of Limnology and Oceanography, Special Publication 21.

PATRICK, R., B. CRUM, AND J. COLES. 1969. Temperature and manganese as determining factors in the presence of diatom or blue-green floras in streams. Proc. Nat. Acad. of Sci. 64(2):472–478.

RUSHFORTH, S. L., L. L. ST. CLAIR, M. C. WHITING, AND T. A. LEWLIE. In press. The algae of Utah Lake. Great Basin Naturalist Memoirs No. 3.

SNOW, E. 1932. A preliminary report on the algae of Utah Lake. Proc. Utah Acad. Sci. 9:21–28.

TANNER, V. M. 1930. Fresh water biological studies at Utah Lake. Proc. Utah Acad. of Sci. 7:60–61.

______. 1931. Fresh water studies at Utah Lake. Part 2. Utah Acad. Sci. 8:199–203.

TARAS, M. J., A. E. GREENBERG, R. D. HOAK, AND M. C. RAND, eds. 1971. Standard methods for the examination of water and waste water. 13th ed. Amer. Pub. Health Service Pub.

BASIDIOMYCETES THAT DECAY JUNIPERS IN ARIZONA. II[1]

R. L. Gilbertson[2] and J. P. Lindsey[2]

Abstract.— Five additional species of wood rotting basidiomycetes on Arizona junipers are described and illustrated. All cause a white rot of dead, fallen trees. *Leptosporomyces juniperinus* is proposed as a new species. *Vararia fibra* is reported from the United States for the first time.

Twenty-seven species of wood-rotting basidiomycetes were previously reported on junipers in Arizona (Gilbertson and Lindsey 1975). Since then five additional wood-rotting fungi have been found on Arizona junipers, all on dead fallen trees. This paper presents information on these species. Scanning electron microscopy was done with an ETEC Autoscan. Capitalized color names are from Ridgway (1912). Voucher specimens are deposited in the Mycological Herbarium of the University of Arizona (ARIZ).

Hymenochaete arida Karst.

Hymenochaete arida Karst., in Sacc., Syll. Fung. 9:228. 1891.

Basidiocarps resupinate, effused up to 15 cm, adnate or peeling away at the margin; hymenial surface Buckthorn Brown to Sudan Brown, smooth, finely setulose under 30X lens, not cracking on drying; margin abrupt, fertile; subiculum thin, up to 200 µm thick, with a single layer of setae from the subhymenial and hymenial hyphae; subicular hyphae (Fig. 1b) loosely arranged, interwoven, simple-septate, moderately thick-walled, pale brown, darkening in KOH, with frequent branching, 3–6 µm diam; setae (Fig. 1c-d) abundant, narrowly subulate, becoming thick-walled, dark brown in KOH, 60–100 × 5–8 µm, projecting up to 60 µm, straight or slightly curved with a loose membranous sheath (Figs. 2, 3) that disappears or becomes inconspicuous in KOH or Melzer's reagent; basidia (Fig. 1e) clavate, in loose candelabrums from hyaline subhymenial hyphae (Fig. 1a), 4-sterigmate, 20–22 × 5–6 µm, simple-septate and thick-walled at the base; basidiospores (Fig. 1f) cylindric, 5–7 × 2–2.5 µm, hyaline, smooth, negative in Melzer's reagent.

Hymenochaete arida also decays wood of mesquite (*Prosopis juliflora* (Sw.) DC), a common associate of junipers at the lower limits of the pinyon-juniper type (Gilbertson et al., 1975) in Arizona. It is associated with a white rot. When viewed with a scanning electron microscope, the dark, thick-walled setae are seen to have a loose membranous sheath (Figs. 2, 3). Thin-walled, pale brown setae in early stages of development do not have a sheath. Setae are initiated as subulate, thin-walled hyphal ends originating in loose candelabrums with basidia. Secondary wall material is laid down until a narrow lumen remains. During this process the primary wall apparently separates from the secondary wall and forms a loose, membranous sheath that hangs loosely on the seta with folds and wrinkles. Reeves and Welden (1967) illustrate setae of *Hymenochaete luteo-badia* (Fr.) Hoehn. et Litsch. and *H. berkeleyana* (Mont.) Cke. with a sheath. However, they interpret the sheath as being composed of thin-walled, hyaline hyphae. Although occasional setae of *H. arida* have hyphae appressed to them, the majority have a sheath that is not hyphal in origin.

Voucher Specimen: RLG 11321, on alligator juniper (*Juniperus deppeana* Steud.), Gardner Canyon, Santa Rita Mts., Coronado Nat. Forest, Santa Cruz County, AZ.

---

[1] University of Arizona Agricultural Experiment Station Journal Article 2794.

[2] Department of Plant Pathology, University of Arizona, Tucson 85721.

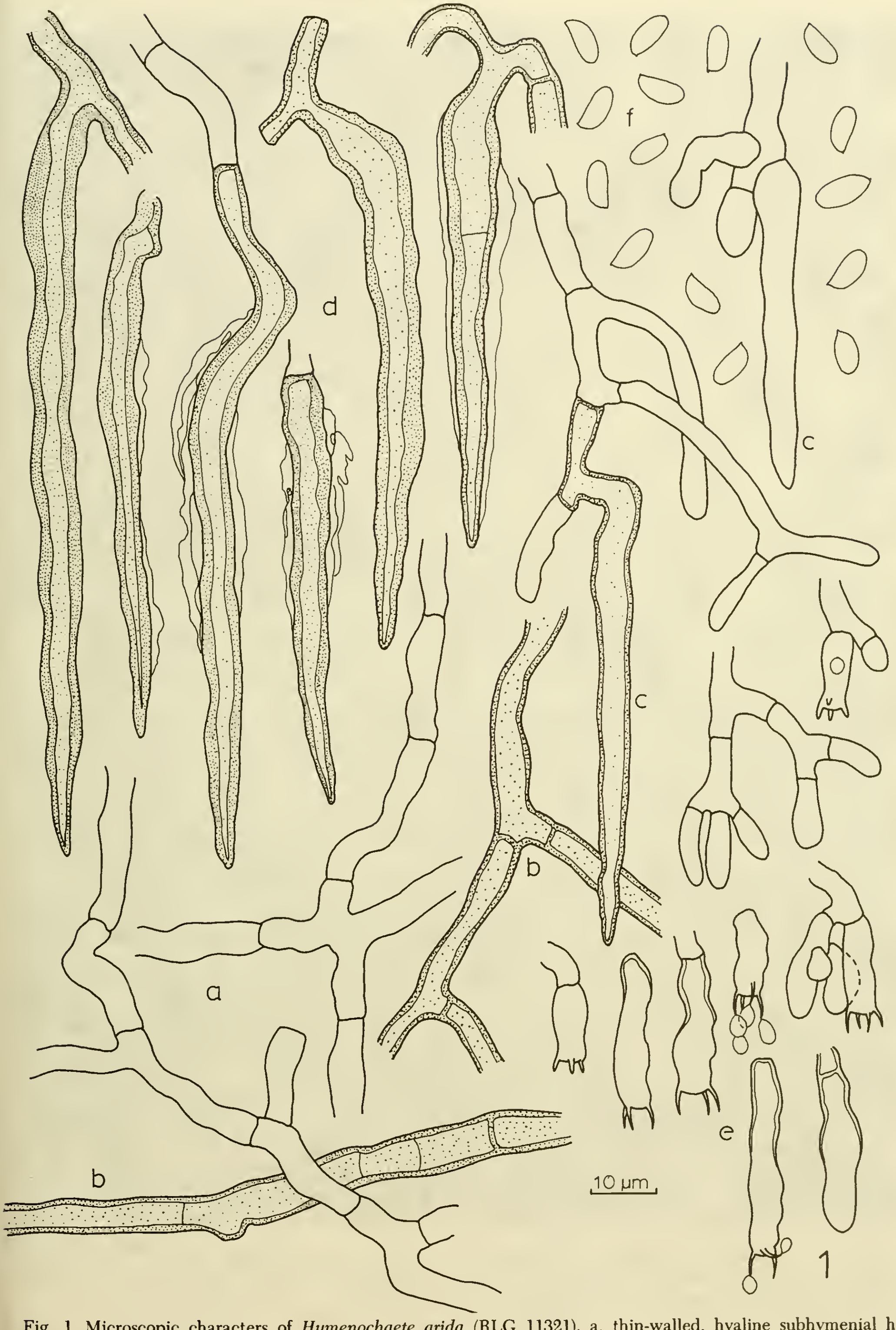
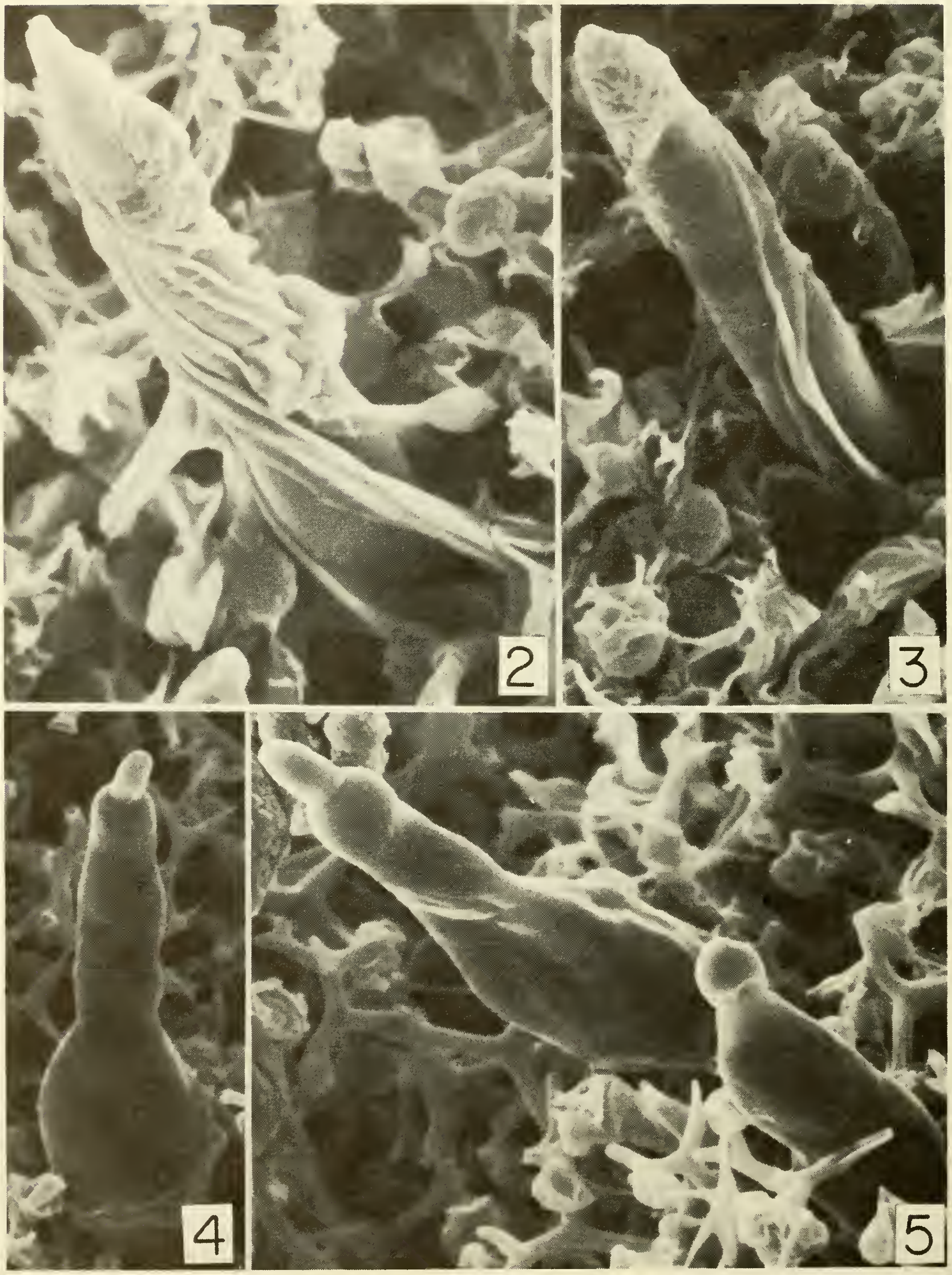


Fig. 1. Microscopic characters of *Hymenochaete arida* (RLG 11321). a, thin-walled, hyaline subhymenial hyphae; b, thick-walled, pigmented hyphae from lower subiculum; c, setae in early stages of development; d, mature setae, some with membranous sheaths; e, basidia; f, basidiospores.



Figs. 2-5. Scanning electron micrographs of hymenial surfaces of *Hymenochaete arida* (RLG 11321) and *Vararia fibra* (RLG 11312). Figs. 2 and 3, setae of *H. arida* showing membranous sheath; Figs. 4 and 5, mammillate gloeocystidia projecting through dichohyphidia of *V. fibra*.

Leptosporomyces juniperinus Gilbn. & Linds., sp. nov.

Fructificatio annua, effusa, alba vel cremea, laevi; rhizomorphae albae; hyphae fibulatae, 2–3 μm diam; cystidia nulla; basidia clavata, 4-sterigmatibus, 8–15 × 4–5 μm; basidiosporae subglobosae, hyalinae, laeve, tenuitunicatae, apiculatae, nonamyloideae, 2.5–3 × 2.5–3.5 μm. Holotypus: R. L. Gilbertson No. 11325, on *Juniperus deppeana* Steud., Gardner Canyon, Santa Rita Mts., Coronado Nat. Forest, Santa Cruz County, Arizona; in herb. National Fungus Collections, Beltsville, MD (BPI).

Basidiocarps becoming widely effused, adnate, cracking into small angular blocks on drying; hymenial surface white to cream-colored, smooth, minutely tomentose; margin thinning out; white mycelial strands present in wood under basidiocarp or at margin; associated with a green alga that becomes incorporated in the subiculum and gives the basidiocarp a greenish tint; hyphal system monomitic; subicular hyphae (Fig. 6a) thin-walled, nodose-septate, 2–3 μm diam, with abundant coarse crystalline material; cystidia or other sterile hymenial structures lacking; basidia (Fig. 6b) in short candelabrums, clavate, 4-sterigmate, 8–15 × 4–5 μm, with a basal clamp; basidiospores (Fig. 6c) subglobose, thin-walled, 2.5–3 × 2.5–3.5 μm, hyaline, smooth, negative in Melzer's reagent, with a prominent apiculus.

Leptosporomyces juniperinus is associated with a white laminated rot with white mycelial strands developing between the layers of wood. Jülich (1972) in his monograph of the Athelieae describes an unidentified fungus (*Leptosporomyces* spec. 8650, p. 210) that is similar to *L. juniperinus*. The subglobose spores of *L. juniperinus* distinguish it from the other described species in *Leptosporomyces*. The alga associated with this fungus is a species of the genus *Chlorococcum* Fries.

Voucher Specimen: RLG 11325, on alligator juniper, Gardner Canyon, Santa Rita Mts., Santa Cruz County, AZ.

Stromatoscypha fimbriata (Pers. ex Fr.) Donk

Stromatoscypha fimbriata (Pers. ex Fr.) Donk, Reinwardtia 1:219. 1951.

Porotheleum fimbriatum Pers. ex Fr., Syst. Myc. 1:506. 1821.

Basidiocarps annual, resupinate, becoming widely effused, readily separated from substratum; pore surface white to cream-colored, the tubes arising after the development of apical pores in isolated papillae that become crowded and confluent; pores circular to angular, 3–5 per mm in mature specimens, margin concolorous, soft, rhizomorphic, usually widely sterile; subiculum white, soft-fibrous, up to 1 mm thick; hyphal system dimitic; subicular generative hyphae (Fig. 7a) thin-walled, nodose-septate, 2.5–3.5 μm diam; subicular skeletal hyphae (Fig. 7b) thick-walled, aseptate, with rare branching, 2–2.5 μm diam; cystidia or other sterile hymenial elements lacking; basidia (Fig. 7c) clavate to cylindric, 4-sterigmate, 23–30 × 5–6 μm, with a basal clamp; basidiospores (Fig. 7d) short-cylindric to ellipsoid, hyaline, smooth, negative in Melzer's reagent, 5–5.5 × 2.5–3 μm.

Stromatoscypha fimbriata has been found on many hardwoods and conifers and causes a white rot.

Voucher Specimen: RLG 11324, on alligator juniper, Gardner Canyon, Santa Rita Mts., Coronado Nat. Forest, Santa Cruz County, AZ.

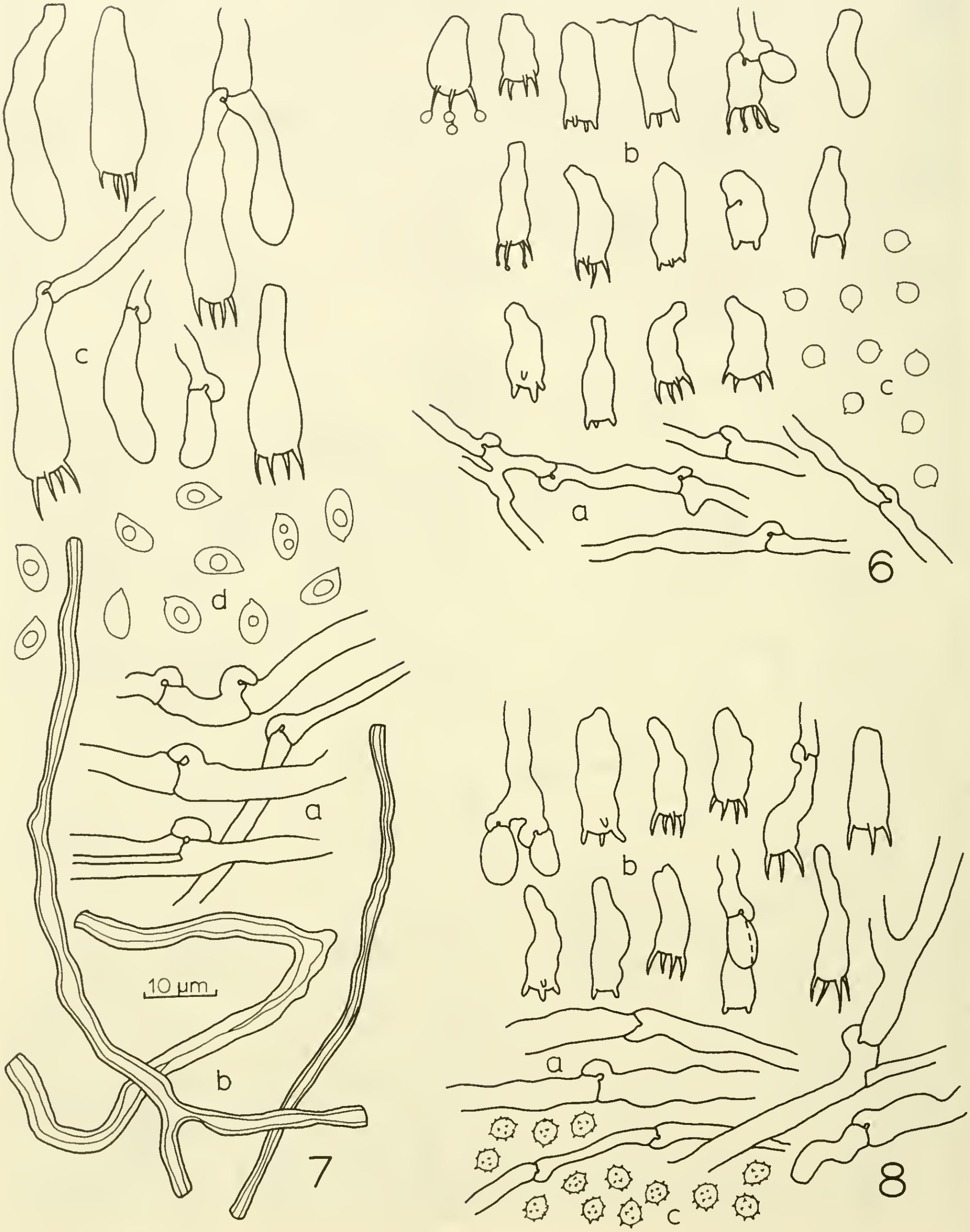
Trechispora farinacea (Pers. ex Fr.) Liberta

Trechispora farinacea (Pers. ex Fr.) Liberta, Taxon 15:318. 1966.

Hydnum farinaceum Pers. ex Fr., Syst. Myc. 1:419. 1821.

Basidiocarps annual, resupinate, thin and fragile; hymenial surface white to pale buff, grandinioid to hydnaceous; margin floccose, often rhizomorphic; hyphal system monomitic; subicular hyphae (Fig. 8a) thin-walled, nodose-septate, frequently ampullate, 2–3.5 μm diam; cystidia and other sterile hymenial elements lacking; basidia (Fig. 8b) short-cylindric to clavate, 4-sterigmate, 3.5–5 μm diam and up to 15 μm long, with a basal clamp; basidiospores (Fig. 8c) ellipsoid to subglobose, echinulate, hyaline to pale yellow, negative in Melzer's reagent, 3–4 × 2–3 μm.

Trechispora farinacea is associated with a white rot of conifer and hardwood logs and slash.



Figs. 6-8. Microscopic characters of: 6, *Leptosporomyces juniperinus* (RLG 11325). a, subicular hyphae; b, basidia; c, basidiospores; 7, *Stromatoscypha fimbriata* (RLG 11324). a, generative subicular hyphae; b, skeletal subicular hyphae; c, basidia; d, basidiospores; 8, *Trechispora farinacea* (RLG 11326). a, subicular hyphae; b, basidia; c, basidiospores.

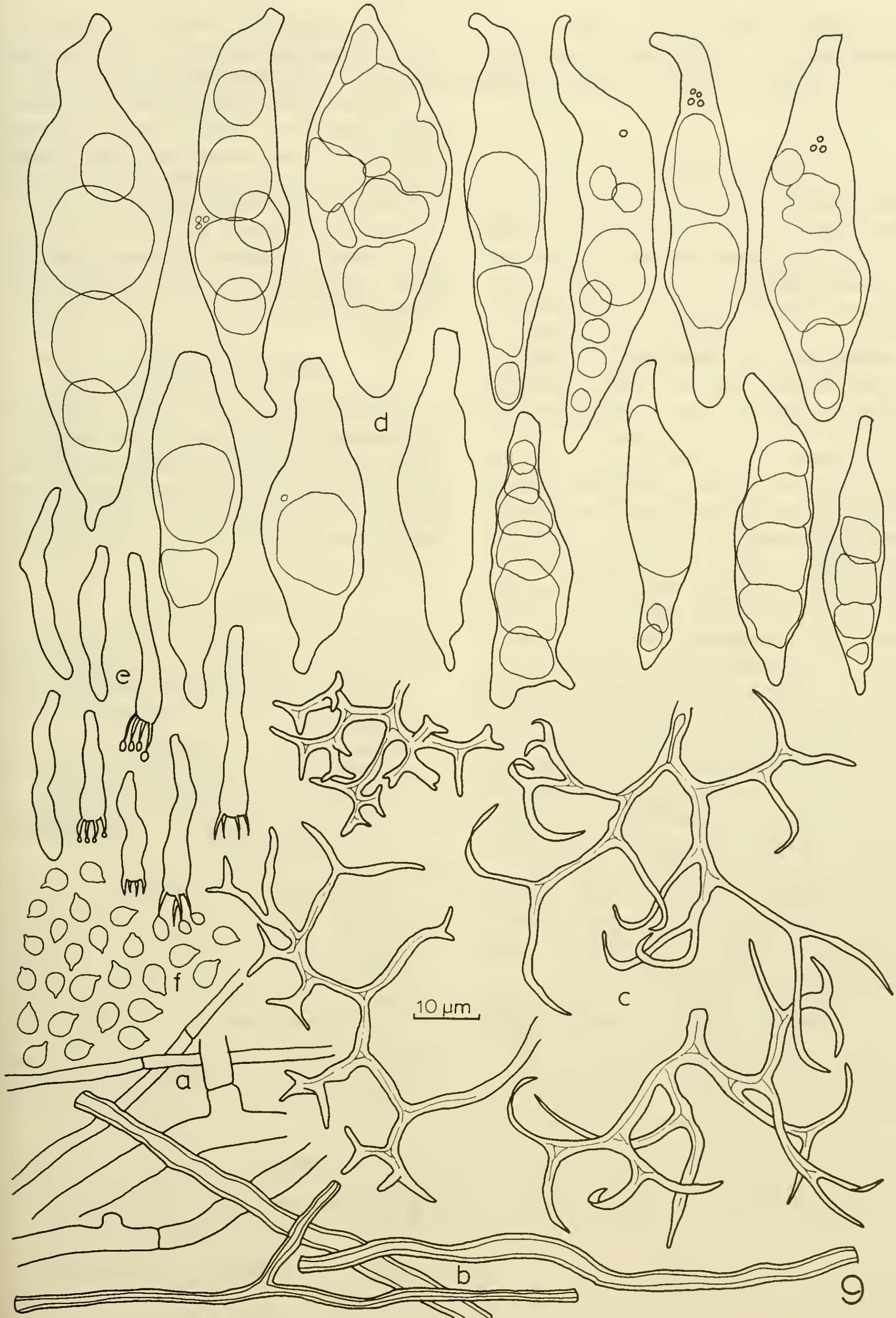


Fig. 9. Microscopic characters of *Vararia fibra* (RLG 11312). a, thin-walled, simple-septate subicular hyphae; b, thick-walled, aseptate fiber hyphae; c, dichohyphidia; d, gloeocystidia; e, basidia; f, basidiospores.

Voucher Specimen: RLG 11326, on alligator juniper, Garden Canyon, Santa Rita Mts., Coronado Nat. Forest, Santa Cruz County, AZ.

Vararia fibra Welden

Vararia fibra Welden, Mycologia 57:507. 1965.

Basidiocarps annual, resupinate, effused up to 5 cm, easily separated from substratum; hymenial surface pale buff, minutely tomentose, cracking into small angular blocks on drying, smooth or assuming the configuration of underlying rhizomorphs; margin thinning out, tomentose to floccose, concolorous, with coarse rhizomorphs that originate in the subiculum and form a network under the hymenial layer; subicular hyphae of two types, some simple-septate (Fig. 9a), thin-walled, some partially to completely incrusted, with frequent branching, 2–5 μm diam; fiber hyphae (Fig. 9b) thick-walled, aseptate, with rare branching, 1.5–4 μm diam; dichohyphidia (Fig. 9c) occasional to abundant, with profuse dichotomous branching, strongly dextrinoid in Melzer's reagent, with ultimate branches slender and recurved, less than 1 μm diam; gloeocystidia (Fig. 9d) abundant, fusoid to capitate or mammillate, thin-walled, with large refractive globules, very weakly positive in sulfuric benzaldehyde, 45–75 × 8–20 μm, with a basal septum; basidia (Fig. 9e) narrowly clavate, 4-sterigmate, 20–28 × 3–3.5 μm, with a basal septum; basidiospores (Fig. 9f) ovoid, hyaline, smooth, negative in Melzer's reagent, with a prominent apiculus, 3–4 × 2–3 μm.

Vararia fibra has previously been reported only from Jamaica. It is associated with a white rot of dead juniper and oak in southern Arizona. *Vararia fibra* is similar to *Vararia ochroleuca* (Bourd. & Galz.) Donk. As pointed out by Welden (1965) and Boidin and Lanquetin (1975), *V. ochroleuca* lacks rhizomorphs and fiber hyphae and has spores that are more subglobose than those of *V. fibra*. The scanning electron microscope shows the typical catahymenium (Figs. 4, 5) with mammillate gloeocystidia and basidia projecting through the loose surface layer of dichohyphidia.

Voucher Specimen: RLG 11317, on alligator juniper, Gardner Canyon, Santa Rita Mts., Coronado Nat. Forest, Santa Cruz County, AZ.

ACKNOWLEDGMENTS

This research was supported by McIntire-Stennis Project 2016-4166-23. We thank Jerrolyn Campbell of the Department of Anatomy, University of Arizona College of Medicine, for help with the scanning electron microscope studies.

LITERATURE CITED

BOIDIN, J. AND P. LANQUETIN. 1975. *Vararia* subgenus *Vararia* (Basidiomycètes Lachnocladiaceae): Étude spéciale des espèces d'Afrique intertropicale. Bull. Soc. Mycol. France 91(4):457–513.

GILBERTSON, R. L., H. H. BURDSALL, JR., AND E. R. CANFIELD. 1976. Fungi that decay mesquite in southern Arizona. Mycotaxon 3(3):487–551.

GILBERTSON, R. L. AND J. P. LINDSEY. 1975. Basidiomycetes that decay junipers in Arizona. Great Basin Nat. 35(3):288–304.

JÜLICH, W. 1972. Monographie der Athelieae (Corticiaceae, Basidiomycetes). Willdenowia, Beih. 7, 283 p.

REEVES, F. JR. AND A. L. WELDEN. 1967. West Indian species of *Hymenochaete*. Mycologia 59:1034–1049.

RIDGWAY, R. 1912. Color standards and color nomenclature. Washington, D.C. Published by the author.

WELDEN, A. L. 1965. West Indian Species of *Vararia* with notes on extralimital species. Mycologia 57:502–520.

PINUS LONGAEVA IN THE STANSBURY MOUNTAINS, UTAH

P. A. Kay[1] and C. G. Oviatt[1]

Abstract.— A new record of *Pinus longaeva* D. K. Bailey in the Stansbury Mountains, north of the known range of the species, is reported.

Bristlecone pine (*Pinus longaeva* D. K. Bailey) occurs in the Great Basin on high ridges and plateaus, which are often exposed. In Utah, the northern-most documented occurrences of *Pinus longaeva* are at about 40 degrees north latitude in the Deep Creek Mountains, Tooele County, and above the Bad Land Cliffs, Duchesne County (Fig. 1). Johnson (1970:25) indicated presence of the species in the western Uinta Mountains, Summit and Duchesne counties, but Bailey (1970, Fig. 3) mapped the Uintas only as a possible habitat without documented occurrence. Bailey (1970, Fig. 3) also showed the Stansbury Mountains, Tooele County, as a possible but unproven location. During recent dendroclimatological field research, the authors discovered a living bristlecone pine in the Stansbury Mountains, well north of the known range limit.

Deseret Peak, at 3362 m, is the highest point in the Stansbury Mountains. The mountain bears considerable evidence of Quaternary glaciation, in the form of cirques, U-shaped valleys, and moraines.

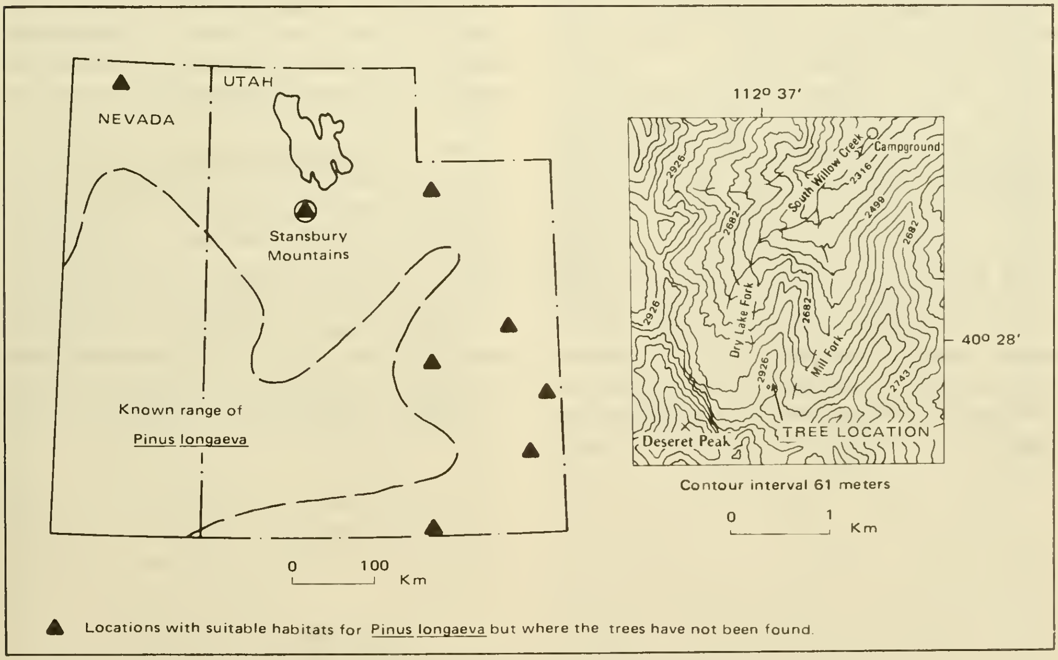

UTAH
NEVADA
Stansbury
Mountains
Known range of
Pinus longaeva
0
100
Km
112° 37′
40° 28′
Campground
South Willow Creek
Dry Lake Fork
Mill Fork
2926
2682
2316
2499
2743
TREE LOCATION
Deseret Peak
Contour interval 61 meters
0
1
Km
Locations with suitable habitats for Pinus longaeva but where the trees have not been found.

Fig. 1. Location map. Range of *Pinus longaeva* from Bailey (1970, Fig. 2). Site location from Deseret Peak quadrangle, U.S. Geological Survey 15-minute topographic series.

---

[1] Department of Geography, University of Utah, Salt Lake City, Utah 84112.

The bristlecone pine is located northeast of the peak, at about 2960 m on the east side of the arête between Dry Lake Fork and Mill Fork (Fig. 1). The tree is at the head of a steep NNE-trending couloir (slope about 47 degrees) cut into the ESE-facing slope, and is about 25-30 m below the highest point of the ridge. The site is steep and rocky, and is exposed to direct sunlight and wind. Soil, only locally present, is thin, stony, coarse sand. The pine appears to be rooted directly in the light-colored quartzite bedrock (Cambrian Tintic quartzite; Rigby 1958).

Other tree species in the vicinity of the bristlecone pine include *Pinus flexilis* James, *Picea engelmannii* Parry, *Pseudotsuga menziesii* (Mirb.) Franco, and *Abies lasiocarpa* (Hook.) Nutt. Ground cover consists of a few scattered clumps of grasses and composites. Two standing snags a few meters uphill from the bristlecone pine have form and bark similar to the live pine, but positive identification was not possible. No other bristlecone pines, dead or living, were found in the immediate area.

The tree is of erect form, about 7.5 m tall. The single trunk (55 cm diameter) divides about 1 m above the ground into three major fastigate limbs, of which two are dead. Branches are pendulous, but the crown is compact. A major root extends along the ground surface for some 3 m uphill, perhaps indicating down-slope movement. The cambium shows evidence of extensive dieback; two strips of live material cover perhaps one-third of the surface of the trunk. Needles, each about 20–25 mm long, occur in fasicles of five. Each needle bears two resin ducts, but only a very few needles have resin exudations. A single open cone was on the tree and was collected. It is about 90 mm long, has a rounded bottom, bears over 100 scales, and has fine reduced bristles. The morphological characteristics are consistent with classification as *Pinus longaeva* (Bailey 1970). A voucher specimen of a twig and the cone is housed in the Garrett Herbarium, University of Utah.

A preliminary examination of a radial core, obtained with an increment borer, indicates 1225 annual rings.

The occurrence of *Pinus longaeva* on quartzite, while not unprecedented, is somewhat unusual. The species is usually found on limestone or dolomite, perhaps because of competition experienced on other substrates (Bailey 1970). In the Stansbury Mountains, the ridge on the east side of Mill Fork is Cambrian Teutonic limestone (Rigby 1958). A search of that ridge might reveal more bristlecone pine individuals.

The authors gratefully acknowledge the assistance in the field of W. E. Riebsame and Jeanne Kay. Additional specimens were found by Riebsame in June 1978.

LITERATURE CITED

Bailey, D. K. 1970. Phytogeography and taxonomy of *Pinus* subsection *Balfourianae*. Ann. Miss. Bot. Gard. 57:210–249.

Johnson, C. M. 1970. Common native trees of Utah. Special Report 22, Agricultural Experimental Station, Utah State University, Logan. 109 pp.

Rigby, J. K. 1958. Geology of the Stansbury Mountains, Tooele County, Utah. Guidebook to the geology of Utah #13, Utah Geological Society, Salt Lake City. 175 pp.

DIFFERENTIAL PARASITISM OF *PEROMYSCUS MANICULATUS* AND *PEROMYSCUS TRUEI* BY *CUTEREBRA* LARVAE

Jeffrey B. Llewellyn[1]

Abstract.— During a 21-month field study of sympatric *Peromyscus maniculatus* (Deer Mouse) and *Peromyscus truei* (pinyon mouse), 12/152 (7.9 percent) *P. maniculatus* and 1/45 (2.2 percent) *P. truei* were parasitized by *Cuterebra* larvae. Both parasitized *P. maniculatus* and *P. truei* and nonparasitized *P. maniculatus* selected different habitats in the community. Differential parasitism of *P. maniculatus* and *P. truei* was possibly caused by host specificity of *Cuterebra*, whereas differential parasitism of *P. maniculatus* may have been due to habitat selection.

Cuterebrid flies are widely distributed in North and South America where their larvae are found embedded in the subcutaneous tissues of many rodents (chipmunks, deer mice, wood rats, etc.), rabbits, and sometimes cats, dogs, deer, cattle, humans, and other mammals (Sillman and Smith 1959, Catts 1965). They have also been found in birds (Artmann 1975). Frequently, certain species of *Peromyscus* (deer mice) harbor *Cuterebra* (botfly) larvae while other species of *Peromyscus* apparently do not. Why one species is parasitized, but a second closely related species is not parasatized, is not fully understood.

During a 21-month field study of sympatric *Peromyscus maniculatus* (deer mouse) and *Peromyscus truei* (pinyon mouse), differential parasitism of the two species by *Cuterebra* larvae was found. Whitaker (1968) suggested that differential parasitism of *Peromyscus* may be caused by a species not being in the right place under the proper conditions to be parasitized, or *Cuterebra* will not parasitize certain species. Previous field investigators have found a correlation between the habitat and parasitism of a species, and laboratory experiments have shown a strong degree of host specificity by *Cuterebra*. I suggest that these two factors caused certain *P. maniculatus*, but not *P. truei*, to be parasitized.

Materials and Methods

Sympatric populations of *P. maniculatus* and *P. truei* were monitored from April 1975 through December 1976 by live trapping in a permanent 1.4 hectare study plot at an elevation of 2025 meters. The study plot was located in the Geiger Grade portion of the Virginia Range, which is situated about 18 km SE of Reno, and 10 km NW of Virginia City, Nevada.

The Geiger Grade area consists of a pinyon-juniper woodland dominated by single-leaf pinyon (*Pinus monophylla*) and Utah juniper (*Juniperus osteosperma*). Between the trees and in the larger open areas a total of 15–20 species of shrubs are found. The most common of these include low sagebrush (*Artemisia arbuscula*), snakeweed (*Gutierrezia sarothrae*), Mormon tea (*Ephedra viridis*), bitterbrush (*Purshia tridentata*), and big sagebrush (*Artemisia tridentata*). Numerous boulder piles and talus rock slides, in which *P. truei* are abundant, occur throughout the area (for a complete description of the area see Llewellyn 1977).

From 25 April 1975 to 21 October 1976, the study plot was sampled for three successive nights on a biweekly basis, using 140 Sherman live traps situated at 10 m intervals. Four additional nights of trapping were completed during a rainy period in August 1975; only one three-night sequence was completed in May 1976; and the last sequence in October 1976 consisted of four trap periods. In November and December of 1976, a five-night sequence was completed during the middle of each month. During the 21-month period, there was a total of 129 trap periods and 18,060 trap nights.

---

[1] Department of Biology, University of Nevada, Reno, Nevada 89557.

The traps were baited with dry, rolled oats, provided with cotton for insulation during the colder months, and checked for captures in the early morning. All individuals captured were sexed, weighed, checked for reproductive condition, marked by toe-clipping, and released at the point of capture. Traps in which a capture was made were thoroughly washed and cleaned before being used again, and all traps were checked for proper working condition as they were being placed at the trap stations.

Because of the nature of the long-term study (Llewellyn 1977), no adult parasites were collected. Consequently, the species of *Cuterebra* was not identified.

RESULTS

Totals of 152 *P. maniculatus* (73 females and 79 males) and 45 *P. truei* (17 females and 28 males) were captured during the 21-month period, and of these, 12 *P. maniculatus* (7.9 percent) and one *P. truei* (2.2 percent) were parasitized (Table 1). The infected *P. truei* in May and June of 1976 represents the same individual (a male), and in both instances one larva was located on the lower left side of the back. The infected *P. maniculatus* in October and November of 1975 also represents the same individual. Of the 12 parasitized *P. maniculatus*, 8 were females and 4 were males, 9 individuals contained one larva, 2 contained 2 larvae, and one individual contained 3 larvae. Only one *P. maniculatus* was parasitized on more than one occasion.

TABLE 1. Incidence of parasitism by *Cuterebra* larvae in *Peromyscus maniculatus* and *Peromyscus truei* from April 1975 through December 1976.*

Months	Number of *P. maniculatus* captured	Number of *P. truei* captured
April 1975	25 (0)	0 (0)
May	42 (1)	0 (0)
June	24 (0)	6 (0)
July	27 (0)	6 (0)
August	19 (0)	7 (0)
September	12 (0)	6 (0)
October	15 (1)	7 (0)
November	8 (1)	7 (0)
December	5 (1)	8 (0)
January 1976	6 (1)	5 (0)
February	13 (2)	6 (0)
March	9 (0)	4 (0)
April	5 (1)	4 (0)
May	4 (2)	5 (1)
June	5 (1)	5 (1)
July	6 (0)	14 (0)
August	3 (0)	10 (0)
September	9 (0)	12 (0)
October	5 (1)	4 (0)
November	3 (0)	3 (0)
December	7 (1)	1 (0)

*Numbers in parentheses represent parasitized individuals.

Most workers have found the principal site of infestation in the inguinal or scrotal region (Whitaker 1968), although Seaman and Nash (1976) reported that 79.5 percent of the infestations in 87 *P. maniculatus* occurred in the rump region. In this study, all of the larvae were located on the back or on the sides. Most workers have also found that the most important period of infection was during the fall (Whitaker 1968), although Brown (1965) found a spring and a fall period in *P. boylii* (brush mouse), and Wecker (1962) and Hunter et al. (1972) found the highest percentages from July through October in *P. leucopus* (white-footed mouse) and *P. maniculatus*. In this study, parasitized individuals were generally found throughout the year, except from July through September of both years (Table 1).

DISCUSSION

Blair (1941, 1942) found that rodents inhabiting forest environments were parasitized by *Cuterebra*, while rodents inhabiting grasslands or more open areas were not parasitized, and he suggested there possibly was a correlation between the habitat and parasitism of a species. In northern Michigan, Blair (1941, 1942) found that *P. maniculatus gracilis*, *Tamias striatus* (eastern chipmunk), and *Napaeozapus insignis* (woodland jumping mouse), all woodland species, were infested, but in southern Michigan *P. maniculatus bairdi*, a field form, was not infested, while *P. leucopus*, a woodland species, was heavily infested. Goertz (1966) also reports differential parasitism by *Cuterebra* in conjunction with differential habitat selection. Goertz (1966) found that *P. leucopus* and *Neotoma floridana* (eastern woodrat), both associated with woodlands, had a high incidence of infestation, but plains and grassland rodents had exceptionally few parasites. Whitaker (1968) also reports differential parasitism of woodland *P. leucopus* and grassland *P. maniculatus bairdi.*

In this study, parasitized *P. maniculatus* and *P. truei* and nonparasitized *P. maniculatus* selected different habitats in the study plot. The mean distance to the nearest tree for the 140 trap stations was 1.51 m (some of the stations were located beneath trees, while others were up to and beyond 5 m). During the 21-month period *P. maniculatus* was captured at 122 stations, with a mean tree distance of 1.44 m, and avoided 18 stations with a mean tree distance of 1.99 m, while *P. truei* was captured at 82 stations with a mean tree distance of 0.86 m, and avoided 58 stations with a mean tree distance of 2.39 m. The mean tree distance for parasitized and nonparasitized *P. maniculatus* was 0.66 m and 1.53 m respectively ($p<0.10$, Mann-Whitney and Student's T-Tests), while the mean tree distance of parasitized *P. maniculatus* and *P. truei* was not significantly different.

If differential habitat selection is a cause of differential parasitism by *Cuterebra*, then such factors as moisture, soil temperature, or vegetation may possibly be responsible. *Cuterebra* apparently lay their eggs on vegetation and not directly on the host (Baird 1974); after the larvae leave the host they burrow into the soil and pupate (Sillman and Smith 1959); and Layne (1963) found little or no infestation in *P. floridanus* (Florida mouse) in drier habitats.

Differential parasitism could also be caused by host specificity of *Cuterebra*. In a field study Seaman and Nash (1976) found that 87/633 *P. maniculatus* (13.7 percent) and 1/170 *P. difficilis* (0.6 percent) were infested with *Cuterebra* larvae. These findings are noteworthy because *P. difficilis* (rock mouse) and *P. truei* are classified in the same *Peromyscus* group (Hall and Kelson 1959), and the two species generally select the same type of habitats (Baker 1968). In a laboratory study Penner and Pocius (1956) introduced larvae of *C. fontinella* (tentative identification) into 10 species of mammals, and development occurred in *Mus musculus* (house mouse), *Rattus rattus* (Black rat), *R. norvegicus* (Norway rat), and *P. leucopus*, but not in kittens, guinea pigs, wild and domestic rabbits, *Microtus pennsylvanicus* (meadow vole), *Sigmodon hispidus* (hispid cotton rat), and *P. maniculatus.* In another laboratory experiment Catts (1965) introduced larvae of *C. approximata* into *Cricetus auratus* (hamster), *Neotoma fuscipes* (dusky-footed woodrat), and the natural host *P. maniculatus. Neotoma fuscipes* proved to be refractory; 6.2 percent of the separate exposures in the hamsters resulted in positive infection; and 44 percent of the separate exposures in *P. maniculatus* resulted in positive infection. In a second experiment Catts (1965) introduced larvae of *C. latifrons* into nine species of rodents and one rabbit, and infection occurred in *Cr. auratus, R. rattus, M. musculus*, and the natural host *N. fuscipes*. However, only in *N. fuscipes* was the net production of fully developed larvae high (67 percent), as compared with 25 percent in *Cr. auratus,* 7 percent in *R. rattus*, and 0 percent in *M. musculus*, and Catts (1965) concluded that susceptibility to infection by *Cr. auratus, R. rattus*, and *M. musculus* does not necessarily confirm their suitability as a host. *Peromyscus maniculatus* was also infected with larvae of *C. latrifrons* in the same experiment, but appeared refractory.

I conclude that differential parasitism of *P. maniculatus* and *P. truei* was possibly caused by host specificity of *Cuterebra*, whereas differential parasitism of *P. maniculatus* may have been due to habitat selection. Apparently, *P. truei* and parasitized *P. maniculatus* were in the right place under the proper conditions to be infected, but only *P. maniculatus* was infected because of structural, physiological, or behavioral differences. Nonparasitized *P. maniculatus* evidently were not in the proper place.

This hypothesis is offered only as a tentative one, since more experimental evidence is needed before definite conclusions can be made.

ACKNOWLEDGMENTS

I would like to thank Dr. Stephen H. Jenkins and Dr. Robert W. Mead, University of Nevada, Reno, for reading an earlier draft of the manuscript, and Mr. Paul Lazaris, President, Lake Tahoe Recreational Land Co. Inc., for pemission to use the area on which the permanent study plot was located. Financial support was received from the Department of Biology, University of Nevada, Reno, and from a Merchant Scholarship awarded by the University of Northern Iowa, Cedar Falls.

LITERATURE CITED

ARTMANN, J. W. 1975. *Cuterebra* parasitism of an American woodcock. J. Parasitol. 61: 65.

BAIRD, C. R. 1974. Field behavior and seasonal activity of the rodent botfly, *Cuterebra tenebrosa*, in central Washington (Diptera: Cuterebridae). Great Basin Nat. 34: 247–253.

BAKER, R. H. 1968. Habitats and distribution, pp. 98–126. *In*: J. A. King, ed., Biology of *Peromyscus* (Rodentia). Spec. Publ. No. 2, Amer. Soc. Mammal. 593 p.

BLAIR, W. F. 1941. Some data on the home ranges and general life history of the short-tailed shrew, red-backed vole, and woodland jumping mouse in northern Michigan. Amer. Midland Nat. 25: 681–685.

______. 1942. Size of home range and notes on the life history of the woodland deer-mouse and eastern chipmunk in northern Michigan. J. Mammal. 23: 27–36.

BROWN, L. N. 1965. Botfly parasitism in the brush mouse and white-footed mouse in the Ozarks. J. Parasitol. 51: 302–304.

CATTS, E. P. 1965. Host-parasite interrelationships in rodent botfly infections. Trans. N. Amer. Wildl. Nat. Resour. Conf. 30: 184–196.

GOERTZ, J. W. 1966. Incidence of warbles in some Oklahoma rodents. Amer. Midland Nat. 75: 242–245.

HALL, E. R. AND K. R. KELSON. 1959. The mammals of North America. Ronald Press, New York. 2 vol., 1162 pp.

HUNTER, D. M., R. M. F. S. SADLEIR, AND J. M. WEBSTER. 1972. Studies of the ecology of cuterebrid parasitism in deer mice. Can. J. Zool. 50: 25–29.

LAYNE, J. N. 1963. A study of the parasites of the Florida mouse, *Peromyscus floridanus*, in relation to host and environmental factors. Tulane Studies Zool. 11: 1–27.

LLEWELLYN, J. B. 1977. Competition and coexistence in sympatric populations of *Peromyscus maniculatus* and *Peromyscus truei*. Unpublished Ph.D. Dissertation, Univ. Nevada, Reno. 118 pp.

PENNER, L. R. AND F. P. POCIUS. 1956. Nostril entry as the mode of infection by the first stage larvae of a rodent *Cuterebra*. J. Parasitol. 42: 42.

SEAMAN, R. N. AND D. J. NASH. 1976. Variation in the incidence of botfly larvae (*Cuterebra*) in two sympatric species of *Peromyscus* in northern Colorado. Great Basin Nat. 36: 481–482.

SILLMAN, E. J. AND M. V. SMITH. 1959. Experimental infestation of *Peromyscus leucopus* with larvae of *Cuterebra angustifrons*. Science 130: 165–166.

WECKER, S. C. 1962. The effects of botfly parasitism on a local population of the white-footed mouse. Ecology 43: 561–565.

WHITAKER, J. O. JR. 1968. Parasites, pp. 254–311. *In*: J. A. King, ed., Biology of *Peromyscus* (Rodentia). Spec. Publ. No. 2, Amer. Soc. Mammal. 593 p.

AN ANNOTATED LIST OF THE AQUATIC INSECTS OF SOUTHEASTERN IDAHO, PART III. EPHEMEROPTERA

Robert L. Newell[1] and G. Wayne Minshall[2]

ABSTRACT.— The study revealed representatives of 9 families, 22 genera, and 59 species occurring within the study area. No new species and no new state records were collected, but a number of new localities have been added.

This paper is the third in a series of publications designed to describe the aquatic insect fauna of southeastern Idaho. A map describing the study area is presented in Newell and Minshall (1977).

The Ephemeroptera, or mayflies, are perhaps the best known and most extensively studied group of aquatic insects. Mayflies are often a diverse and abundant component of the benthic fauna of streams in the western United States. In North America north of Mexico there are 60 genera and 622 species of mayflies (Edmunds et al. 1976).

Information on the geographical distribution of mayflies is widely scattered throughout published sources. Unfortunately, much of these data are useless for this report since many authors listed species only as "collected in Idaho" and did not supply definite locations. The mayfly fauna of Idaho was poorly known until Jensen's (1966) study "Mayflies of Idaho." Jensen's thorough work reviews the literature and provides keys to nymphs and adults of the 85 species of mayflies known from Idaho. However, the work remains unpublished and therefore is generally inaccessible to a wide number of workers. Hornung and Barr (1970) also reported some mayfly distribution data.

A total of 9 families, 22 genera, and 59 species are reported from southeastern Idaho. No new species and no new state records were collected, but a number of new localities were added. An undescribed species of *Stenonema* (Edmunds et al. 1976) also is known from southeastern Idaho. The genus *Pseudocloeon* is reported here and not in the checklist, since the species are not identified.

The authors thank the many people who contributed time, effort, and specimens for this study. They also thank Dr. W. L. Peters for identifying some of the specimens.

FAMILY SIPHLONURIDAE

1. *Ameletus cooki* McDunnough.— Bannock Co.: Mink Cr.

2. *Ameletus oregonensis* Eaton.— Bannock Co.: Mink Cr. Bonneville Co.: Snake R. (S. Fk.). Butte Co.: Little Lost R. Teton Co.: Teton R.

3. *Ameletus sparsatus* McDunnough.— Bannock Co.: Rapid Cr. Bonneville Co.: Pine Cr. Custer Co.: Big Lost R. Fremont Co.: Snake R. (Henry's Fk.).

4. *Ameletus velox* Dodds.— Butte Co.: Little Cottonwood Cr.; Little Lost R.

5. *Siphlonurus occidentalis* Eaton.— Bear Lake Co.: St. Charles Cr. Blaine Co.: Big Wood R. Bonneville Co.: Rainey Cr. Butte Co.: Big Lost R. Cassia Co.: Cassia Cr. Custer Co.: near Mackay. Fremont Co.: Snake R. (Henry's Fk.). Teton Co.: Teton R.

FAMILY BAETIDAE

6. *Baetis bicaudatus* Dodds.— Blaine Co.: Big Wood R. Bonneville Co.: Pine Cr.; Rainey Cr. Butte Co.: Little Lost R.; stream near Arco. Custer Co.: Big Lost R. Fremont Co.: Targhee Cr. Teton Co.: Badger Cr.

---

[1] Stearns-Roger, Inc., P.O. Box 5888, Denver, Colorado 80217.

[2] Department of Biology, Idaho State University, Pocatello, Idaho 83209.

7. *Baetis insignificans* McDunnough.— Butte Co.: Little Lost R. Gooding Co.: near Tuttle.

8. *Baetis intermedius* Dodds.— Bannock Co.: Indian Cr.; Mink Cr.; Portneuf R. Bingham Co.: Spring Cr. Gooding Co.: Niagara Springs; Riley Cr.

9. *Baetis parvus* Dodds.— Bingham Co. Blaine Co.: Big Wood R. Bonneville Co.: Brockman Cr.; Snake R. (S. Fk.). Jefferson Co.: near Roberts. Teton Co.: Teton R.

10. *Baetis propinquus* (Walsh).— Butte Co.: near Arco.

11. *Baetis quilleri* Dodds.— Gooding Co.

12. *Baetis tricaudatus* Dodds.— Bannock Co.: Portneuf R.; Rapid Cr. Blaine Co.: Big Wood R. Bonneville Co.: Rainey Cr. Butte Co.: Little Lost R.; near Arco. Clark Co.: Beaver Cr.; Birch Cr.; Camas Cr.; Medicine Lodge Cr. Custer Co.: Big Lost R. Fremont Co.: Snake R. (Henry's Fk.). Franklin Co.: Mink Cr. Gooding Co.: Niagara Springs; Snake R. Jefferson Co.: Birch Cr. Jerome Co. Lincoln Co.: N. Gooding Canal. Oneida Co.: Deep Cr. Twin Falls Co.: Salmon Falls Cr.

13. *Callibaetis coloradensis* Banks.— Bear Lake Co.: near Montpelier. Blaine Co.: Sawtooth Nat. Forest. Bonneville Co.: Rainey Cr. Fremont Co.: near St. Anthony. Franklin Co.: Cub R. Jefferson Co.: near Heise. Lincoln Co.: near Dietrich.

14. *Callibaetis montanus* Eaton.— Bannock Co.: near McCammon. Franklin Co.: Bear R. Gooding Co.: Riley Cr.

15. *Callibaetis nigritus* Banks.— Bannock Co.: Mink Cr.; near Arimo; Portneuf R. Bear Lake Co.: near Ovid. Bingham Co.: Clear Cr. Butte Co.: near Howe. Caribou Co.: Portneuf R. Cassia Co.: near Burley. Gooding Co.: Niagara Springs; Riley Cr. Jerome Co.: near Jerome. Lincoln Co.: near Shoshone. Oneida Co.: Deep Cr. Twin Falls Co.: near Twin Falls.

16. *Centroptilum bifurcatum* McDunnough.— Gooding Co.: Twin Falls Co.

17. *Centroptilum selanderorum* Edmunds.— Bingham Co.: Aberdeen-Springfield Canal; Snake R. Blaine Co.: Big Wood R. Butte Co.: Big Lost R. Cassia Co.: at Burley. Custer Co.: Big Lost R. Lincoln Co.: N. Gooding Canal. Oneida Co.: Deep Cr.

FAMILY HEPTAGENIIDAE

18. *Cinygma integrum* Eaton.— Blaine Co.: ditch near Ketchum. Butte Co.: Little Cottonwood Cr.

19. *Cinygmula mimus* (Eaton).— Bannock Co.: Gibson Jack Cr.; Mink Cr. Bonneville Co.: Jensen Cr.

20. *Cinygmula par* (Eaton).— Butte Co.: Little Lost R. Teton Co.: Badger Cr.

21. *Cinygmula ramaleyi* (Dodds).— Bannock Co.: Mink Cr. Cassia Co.: Cassia Cr.

22. *Cinygmula reticulata* McDunnough.— Clark Co.: Birch Cr.

23. *Cinygmula tarda* (McDunnough).— Custer Co.: near Mackay.

24. *Epeorus (Iron) albertae* (McDunnough).— Bannock Co.: Mink Cr. Blaine Co.: near Ketchum. Custer Co.: Big Lost R. Fremont Co.: Snake R. (Henry's Fk.).

25. *Epeorus (Iron) deceptivus* (McDunnough): Blaine Co. Butte Co.: Little Lost R.

26. *Epeorus (Iron) longimanus* (Eaton).— Bannock Co.: Mink Cr.; Portneuf R.; Rapid Cr. Bear Lake Co.: St. Charles Cr. Bonneville Co.: Pine Cr. Fremont Co.: Snake R. (Henry's Fk.). Franklin Co.: Cub R. Teton Co.: Badger Cr. Twin Falls Co.: Rock Cr.

27. *Epeorus (Ironopsis) grandis* (McDunnough).— Bonneville Co.: Pine Cr. Teton Co.: Moose Cr.

28. *Heptigenia criddlei* McDunnough.— Bingham Co.: Clear Cr. Blaine Co.: Richfield Canal. Butte Co.: Hagerman. Lincoln Co.: Gooding Canal.

29. *Heptagenia elegantula* (Eaton).— Lincoln Co.: Gooding Canal. Power Co.: Bannock Cr.

30. *Heptagenia simplicioides* McDunnough.— Bingham Co.: Aberdeen-Springfield Canal. Caribou Co.: Toponce Cr. Lincoln Co.: Big Wood R.

31. *Heptagenia solitaria* McDunnough.— Franklin Co.: Bear R. Fremont Co.: Snake R. (Henry's Fk.). Jefferson Co.: Birch Cr. Teton Co.: Teton R.

32. *Rhithrogena futilis* McDunnough.— Twin Falls Co.: Rock Cr.

33. *Rhithrogena hageni* Eaton.— Bannock Co.: Rapid Cr. Bonneville Co.: Pine Cr. Clark Co.: Birch Cr.; Medicine Lodge Cr. Custer Co.: Big Lost R. Franklin Co.: Cub R. Fremont Co.: Snake R. (Henry's Fk.). Jef-

ferson Co.: Birch Cr. Teton Co.: Badger Cr.

34. *Rhithrogena morrisoni* (Banks).— Bannock Co.: Mink Cr. Bear Lake Co.: Thomas Fork Cr. Blaine Co.: Big Wood R. Butte Co.: Big Lost R. Fremont Co.: Snake R. (Henry's Fk.).

35. *Rhithrogena robusta* Dodds.— Bonneville Co.: Pine Cr. Butte Co.: Little Lost R. Fremont Co.: Teton R. Teton Co.: Moose Cr.

36. *Rhithrogena undulata* (Banks).— Custer Co.: near Mackay.

FAMILY LEPTOPHLEBIIDAE

37. *Choroterpes albiannulata* McDunnough.— Bingham Co.: Snake R. Franklin Co.: Bear R.

38. *Leptophlebia gravastella* (Eaton).— Bannock Co.: Mink Cr. Bonneville Co.: Brockman Cr.

39. *Paraleptophlebia debilis* (Walker).— Blaine Co.: Warm Springs Cr. Butte Co.: Big Lost R. Caribou Co.: Blackfoot R.; Portneuf R. Jerome Co.: near Jerome. Lincoln Co.: N. Gooding Canal.

40. *Paraleptophlebia heteronea* (McDunnough).— Bannock Co.: Mink Cr.; Portneuf R. Bear Lake Co.: Montpelier Cr. Blaine Co.: ditch near Big Wood R. Butte Co.: Little Lost R. Clark Co.: Beaver Cr.; Camas Cr. Custer Co.: Big Lost R. Franklin Co.: Mink Cr. Fremont Co.: Buffalo R. Teton Co.: Teton R.

41. *Paraleptophlebia memorialis* (Eaton).— Butte Co.: near Howe. Custer Co.: Big Lost R. Fremont Co.: Snake R. (Henry's Fk.).

FAMILY EPHEMERELLIDAE

42. *Ephemerella (Atenella) margarita* Needham.— Lincoln Co.: Big Wood R.

43. *Ephemerella (Caudatella) heterocaudata heterocaudata* McDunnough.— Blaine Co.: Trail Cr. Custer Co.: Big Lost R. Fremont Co.: Targhee Cr.

44. *Ephemerella (Caudatella) hystrix* Traver.— Butte Co.: Little Lost R. Fremont Co.: Teton R. (N. Fk.); Targhee Cr.

45. *Ephemerella (Drunella) coloradensis* Dodds.— Bannock Co.: Mink Cr. Blaine Co.: Big Wood R. Bonneville Co.: Pine Cr. Butte Co.: Little Lost R. Clark Co.: near Orgona. Franklin Co.: Mink Cr. Fremont Co.: Howard Cr. Teton Co.: Moose Cr.

46. *Ephemerella (Drunella) doddsi* Needham.— Bannock Co.: City Cr.; Gibson Jack Cr.; Mink Cr.; Portneuf R.; Rapid Cr. Blaine Co.: Big Wood R. Bonneville Co.: Indian Cr.; Jensen Cr.; Pine Cr.; Rainey Cr. Butte Co.: Little Lost R. Franklin Co.: Cub R. Fremont Co.: Targhee Cr. Teton Co.: Moose Cr.; Trail Cr.; Warm Cr.

48. *Ephemerella (Drunella) flavilinea* McDunnough.— Blaine Co.: Big Wood R. Bonneville Co.: Indian Cr.; Rainey Cr. Butte Co.: Little Lost R. Custer Co.: Big Lost R. Fremont Co.: Warm R. Teton Co.: Teton R.

48. *Ephemerella (Drunella) grandis grandis* Eaton.— Bannock Co.: City Cr.; Gibson Jack Cr.; Mink Cr.; Pocatello Cr.; Portneuf R.; Rapid Cr. Bear Lake Co.: St. Charles Cr. Bonneville Co.: Rainey Cr. Butte Co.: Little Lost R. Clark Co.: Beaver Cr.; Birch Cr.; Camas Cr.; Medicine Lodge Cr. Custer Co.: Big Lost R. Franklin Co.: Cub R. Fremont Co.: Snake R. (Henry's Fk.). Teton Co.: Teton R. (N. Fk.).

49. *Ephemerella (Drunella) spinifera* Needham.— Blaine Co.: Big Wood R. Butte Co.: Little Lost R. Fremont Co.: Targhee Cr.

50. *Ephemerella (Ephemerella) inermis* (Eaton).— Bannock Co.: Mink Cr.; Portneuf R.; Rapid Cr. Bear Lake Co.: Salt Cr. Bingham Co.: Snake R. Blaine Co.: Big Wood R.; Silver Cr. Bonneville Co.: Pine Cr. Rainey Cr. Butte Co.: Little Lost R. Cassia Co.: Cassia Cr. Clark Co.: Beaver Cr.; Birch Cr.; Camas Cr.; Medicine Lodge Cr. Custer Co.: Big Lost R. Franklin Co.: Cub Cr.; Mink Cr. Fremont Co.: Warm R. Jefferson Co.: Birch Cr. Lincoln Co.: Little Wood R. Teton Co.: Teton R.; Trail Cr.

51. *Ephemerella (Ephemerella) infrequens* McDunnough.— Bear Lake Co.: Thomas Fork Cr. Bingham Co.: Clear Cr.; Spring Cr. Blaine Co.: Big Wood R. Bonneville Co.: Rainey Cr.; Snake R. (S. Fk.). Clark Co.: Birch Cr. Custer Co.: Big Lost R. Fremont Co.: Warm R.

52. *Ephemerella (Serratella) tibialis* McDunnough.— Bonneville Co.: Pine Cr. Butte Co.: Little Lost R.; Big Lost R. Custer Co.: near Mackay. Franklin Co.: Cub R.

53. *Ephemerella (Timpanoga) hecuba hecuba* (Eaton).— Bingham Co.: Snake R. Custer Co.: Big Lost R. Franklin Co.: Cub R.

FAMILY TRICORYTHIDAE

54. *Tricorythodes minutus* Traver.— Bannock Co.: near Pocatello; Portneuf R. Bingham Co.: Clear Cr.; Spring Cr. Bonneville Co.: Willow Cr. Butte Co.: Big Lost R.; Little Lost R. Cassia Co.: Snake R. Caribou Co.: Blackfoot R.; Portneuf R. Franklin Co.: Bear R. Gooding Co.: Niagara Springs. Jerome Co.: at Hazelton. Lincoln Co.: N. Gooding Canal. Minidoka Co.: Snake R. Oneida Co.: Deep Cr. Power Co.: Snake R. Twin Falls Co.: Salmon Falls Cr.

FAMILY CAENIDAE

55. *Brachycercus prudens* (McDunnough).— Lincoln Co.: N. Gooding Canal.

56. *Caenis simulans* McDunnough.— Bannock Co.: Portneuf R. Butte Co.: Craters of the Moon Nat. Monument. Caribou Co.: Portneuf R. Jerome Co.: near Milner. Lincoln Co.: near Shoshone; N. Gooding Canal. Oneida Co.: Deep Cr.

FAMILY EPHEMERIDAE

57. *Ephemera simulans* Walker.— Fremont Co.: Buffalo R.; Snake R. (Henry's Fk.).

58. *Hexagenia limbata limbata* Serville.— Cassia Co.: near Burley; Snake R. Gooding Co.: at Hagerman; near Gooding. Lincoln Co.: at Shoshone. Minidoka Co.: at Rupert. Power Co.: Snake R.

FAMILY POLYMITARCIDAE

59. *Ephoron album* (Say).— Bannock Co.: Portneuf R. Cassia Co.: Raft R. Franklin Co.: Bear R. Jerome Co.: near Jerome. Lincoln Co.: near Shoshone. Twin Falls Co.: at Twin Falls; near Murtaugh.

LITERATURE CITED

EDMUNDS, G. F., JR., S. L. JENSEN, AND L. BERNER. 1976. The mayflies of North and Central America. Univ. of Minn. Press, Minneapolis. 330 p.

HORNUNG, D. S. AND W. F. BARR. 1970. Insects of Craters of the Moon National Monument Idaho. Univ. of Idaho, Coll. of Agric., Misc. Ser. No. 8, 118 p.

JENSEN, S. L. 1966. The mayflies of Idaho (Ephemeroptera). Unpublished master's thesis, Univ. of Utah, Salt Lake City. 365 p.

NEWELL, R. L. AND G. W. MINSHALL. 1977. An annotated list of the aquatic insects of southeastern Idaho. Part II. Trichoptera. Great Basin Nat. 37:253–257.

OBSERVATIONS ON THE PREY AND NESTS OF SEVEN SPECIES OF *CERCERIS* (HYMENOPTERA: SPHECIDAE)[1]

Howard E. Evans[2] and William L. Rubink[2]

Abstract.— *Cerceris* species are remarkably constant in their prey preferences. Records are presented from diverse localities that confirm prey constancy in five species. An apparent exception is noted in the case of *C. crotonella* Viereck & Cockerell. A mixed aggregation of *C. fumipennis* Say and *C. californica* Cresson is reported, both preying upon Buprestidae and using some of the same species. Nest and prey of *C. conifrons* Mickel are reported for the first time.

One of the striking features of the behavior of species of *Cerceris* is their prey constancy. Even in widely disparate parts of the range, females of a given species tend to utilize beetles of only one family, often of only a few related genera. Such specialization doubtless reduces competition among species nesting together. Evans (1971) reported three species nesting together at Bedford, Massachusetts, each preying upon quite a different kind of weevil; later (1974) he added still a fourth species from this same site, utilizing still a different kind of weevil. Despite their prey specificity, the species of *Cerceris* are remarkably similar in many aspects of their nesting behavior.

In this paper we report still further examples of prey constancy in diverse parts of the ranges of five species. We also report an apparent exception in the case of one species, *C. crotonella* Viereck & Cockerell. Further, we report a mixed aggregation of two closely related species, *C. fumipennis* Say and *C. californica* Cresson, both preying upon Buprestidae, including several of the same species. The first records of the nest and prey of *C. conifrons* Mickel are presented, as well as diverse notes on the nests of other species.

Cerceris simplex macrosticta Viereck & Cockerell

On 20 July 1976, we took a female of this large species flying with her prey over an arroyo 30 km NE of Lordsburg, New Mexico. The prey proved to be a tenebrionid beetle, *Pechalius subvittatus* Casey. On 24 and 31 August 1976, we studied an aggregation of some 40 females of this species about 9 km N of Roggen, Weld Co., Colorado. At this site a single species of Tenebrionidae was being employed as prey, *Bothrotes plumbeus plumbeus* (LeConte) (N = 38, with several additional sight records and several additional records from the same area in 1977). Since Alcock (1974, 1975) has published two excellent papers on *C. simplex macrosticta*, we present only a few notes here. The prey at Alcock's site in Arizona also consisted of a single species of Tenebrionidae, in this case *Metapoloba pruinosa* (Horn) (N = 60, with additional sight records). It is interesting that these three genera, *Metapoloba*, *Bothrotes*, and *Pechalius*, all belong to the tribe Epitragini. Lin (1967) studied *C. simplex graphica* Smith in Oklahoma and found the prey there to consist of a single tenebrionid species, *Eleodes opaca* (Say), a member of a different subfamily. Since the ranges of these two subspecies of *simplex* appear to overlap broadly, thought might be given to the possibility of their being separate species.

At the Roggen site, nests were located in a steep slope of fine-grained sand, mostly devoid of vegetation, where the chief associates were species of *Bembix*, *Microbembex*, and at least two species of bees. *Cerceris*

---

[1] Research supported by the National Science Foundation, grant BNS76-09319.

[2] Department of Zoology and Entomology, Colorado State University, Fort Collins, Colorado 80523.

nests were situated over a distance of some 30–40 m along the bank, but they were definitely clumped in certain places, along with those of the bees. In these clumps nest entrances were often no more than 5–15 cm apart, but the clumps themselves were separated by several meters. Nest entrances were left open while the females were provisioning, and each was surrounded by a rim of sand, as is usual in this genus. A male *macrosticta* was taken on flowers of *Croton texensis* (Klotzsch) not far away, but no males were seen in the nesting area.

During the morning hours, females were frequently seen descending to their nests holding beetles in their mandibles in such a way that they hung down obliquely from the body. They were frequently followed by 1–3 satellite flies, *Senotainia* sp., and when so followed the wasps would often circle widely before entering their nests, making loops several meters in diameter at different heights and occasionally landing on vegetation. One female spent six minutes making an evasive flight of this nature, then finally entered the nest without any flies following her. Only 1 of the 12 cells eventually excavated appeared to have had the contents destroyed by maggots, so we judge that the wasps are often successful in evading satellite flies.

Nest structure agreed closely with that figured by Alcock (1974) for this species. One of the two nests we excavated had five cells, the other seven. Cells varied in depth from 17 to 32 cm ($\bar{x} = 26$, precisely the same figure Alcock obtained in Arizona). In both cases beetles had been stored at various points in the burrow, chiefly near its terminus. The number of beetles per cell was two in one case, three in nine cases, and seven in one case. Most cells measured 10 x 12 mm, but the one containing seven beetles measured 14 x 23 mm. We suspect this was a "female producing cell", the others "male" cells, a situation that is probably common if not universal in *Cerceris*. These figures are also very similar to those obtained by Alcock in Arizona.

Cerceris bicornuta Guérin

This is a relatively well-studied species, and we present only a few notes confirming prey constancy in diverse parts of the range. On 23 July 1975 we took a female *C. bicornuta bicornuta* 14 km W of Laporte, Colorado, carrying a weevil, *Sphenophorus cicatristriatus* Fähraeus in her mandibles. She landed on a dirt road, apparently en route to her nest, and rested there for a moment with her wings extended obliquely above her abdomen.

During the month of July 1976 we observed an aggregation of *C. bicornuta fidelis* Viereck & Cockerell at the LaJoya Wildlife Preserve, 30 km N of Socorro, New Mexico. On 1 July we counted 44 nests in an area 3 x 5 m in flat, hard-packed sandy loam beside a dirt road. About an equal number of *Tachytes aurulentus* (F.) also nested here, and the nests of the two species were somewhat intermingled and rather similar in external appearance, both having a large mound at the entrance and the hole near the center of the mound. However, the *Tachytes* were most active in the early morning, as early as 0630, while the *Cerceris* provisioned their nests over the warm part of the day. The *Cerceris* nests were well spaced, mostly 0.3–1.0 m apart, but some were very close to *Tachytes* nests (in one case only 15 cm from a *Tachytes* nest).

Provisioning females entered the area 1–2 m high and plunged directly into the open nest entrances. Prey was carried in the mandibles as usual in the genus, and consisted of a single species of weevil, *Sphenophorus australis* Chittenden (N = 12). Weevils were stored in the burrow, as usual in this genus. We dug out only one nest in 1976, early in the season and apparently before any cells had been made. The nest had a mound at the entrance measuring 15 x 17 cm, 2.5 cm high, with the burrow penetrating the center. Burrow diameter was 8 mm. This burrow was vertical for 29 cm, then leveled off abruptly and extended another 27 cm before terminating blindly. Three weevils were found about midway in the horizontal part of the burrow.

In July 1977, we made further observations on this same aggregation, though many fewer nests were visible. Three nests were excavated. The first, on 8 July, yielded five weevil prey from the single, recently completed cell. Two species, *Sphenophorus neomexicanus* Chittenden (N = 4) and *S. cicatristriatus* Fähraeus (N = 1) were represented. A second nest, excavated on 12 July, contained no cells and a single weevil, *S. cicatristriatus*, midway down the 25 cm long burrow. The third nest, examined on 27 July, yielded more substantial information on nest structure. However, because of several days of inactivity due to heavy rain, none of the cell contents were suitable for preservation. Seven cells contained from three to seven weevils each, as determined from the prey remains. All cells measured approximately 15 x 30 mm. Two cells, at depths of 11 and 18 cm, contained only intact, decomposing weevil remains. Two others, 13 and 16 cm deep, contained cocoons and remains of weevils. A cell at a depth of 29 cm contained a dipteran larva that died shortly after removal. The two remaining cells, at depths of 24 and 31 cm, contained *Cerceris* larvae 12 and 21 cm long, respectively. Cells were widely spaced, 7–15 cm apart.

Krombein (1960) studied *C. bicornuta fidelis* in Arizona, where the wasps were also making deep nests along the edge of a road. The prey here consisted of the weevil *Eupagoderes* sp., which he found to be common on the flowers of snakeweed. There are several papers dealing with the biology of *C. bicornuta bicornuta* in diverse parts of its range, e.g. Rau (1928), Cartwright (1929), Strandtmann (1945), and Krombein (1953). Scullen and Wold (1969) summarize prey records from five different states (New York, Ohio, Missouri, North and South Carolina), in every case a single genus of weevil, *Sphenophorus*. Evans (1971) added additional records for this genus of weevil from Connecticut, based on unpublished records of Richard Dow.

Cerceris crotonella Viereck & Cockerell

This small species is a common inhabitant of extensive areas of fine-grained sand in Colorado and New Mexico. We have seen prey-laden females carrying small beetles into open holes in sand on several occasions, but we have had no success in finding cells. On 5 July 1975 we captured a female with prey 4 km S of Caddoa, Bent Co., Colorado. The beetle proved to be *Pachybrachys minor* Bowditch (Chrysomelidae). This is in contrast to a record from western Texas of this species preying upon a beetle of the unrelated family Nitidulidae (Evans 1971). Clearly this species will bear further study.

Cerceris conifrons Mickel

This is a small species bearing much resemblance to *crotonella* and belonging to the same species-group (group I of Scullen 1965). On 11 August 1977 a female was seen plunging into an open, oblique burrow along a path at Great Sand Dunes National Monument, Alamosa Co., Colorado. The nest was in fine-grained but rather firm sand in a small open space among low grasses and forbs. There was no mound of soil at the entrance. The female was captured as she left the nest at 1300 hours, and the nest was excavated. The burrow formed about a 30-degree angle with the surface for 17 cm, then went down vertically for another 5 cm, terminating at a vertical depth of 12 cm. There were five very small weevils at the bottom of the burrow, *Epimechus* sp. (Curculionidae). It is probable that these had merely been stored in the bottom of the burrow and that no cell had yet been prepared.

Cerceris echo Mickel

This species resembles the preceding two in size and color and is a member of the same species-group. Records from widely separate parts of the range demonstrate that this species is a specialist on beetles of the family Phalacridae. Evans (1971) reported beetles of this family as prey of *C. echo atrata* Scullen in Lexington, Massachusetts, and as prey of *C. echo echo* Mickel in Cornish, Utah. On 15 August 1977, at the LaJoya State Wldlife Preserve, 30 km N of Socorro, New Mexico, we captured a female *C. echo echo* as she was hovering above her nest with prey. The nest was located in a small bare depression in fine aeolian sand among scattered *Dalea*, *Atriplex*, and bunch grasses, and below the active sand dunes. No tumulus was apparent around the nest entrance. The burrow proceeded vertically 40 cm through very dry, loose soil, then angled sharply, continuing downward at a 30 degree angle with the horizontal, terminating at a depth of 44 cm. Three beetles were found at the angle in the burrow. Two small cells were found at depths of 54 and 62 cm, but no eggs or larvae were visible. These cells contained 19 and 28 prey, respectively. On 1 September, a second nest was found in the same area and excavated. The soil was moist, as a result of recent rains, and the nest was shallower. Although it was not possible to follow the main burrow, a cache of 4 beetles was found at a depth of 24 cm and a cell containing 17 beetles was found at a depth of 27 cm. All the prey in both nests belonged to one of two species of Phalacridae, *Phalacrus* sp. (N = 23) and *Olibrus* sp. (N = 3). Male *C. echo echo* were also common in the area of the nest site and were frequently seen entering burrows, presumably in search of females.

Cerceris fumipennis Say and *C. californica* Cresson

These are both among the best-studied species of this genus, *fumipennis* being mainly an eastern species, ranging west to Wyoming and New Mexico, *californica* a common western species ranging east to Utah and Texas. There are many prey records for both species, summarized by Scullen and Wold (1969); both use a wide variety of Buprestidae. These are related wasps, both belonging to group II of Scullen (1965). It was with considerable interest that we found the two nesting together 11-12 June 1976 at Monahans Sandhills State Park, Ward Co., Texas. About six nests of *C. californica californica* were intermingled with about 30 nests of *C. fumipennis* in slightly sloping soil along the edge of a paved road. The soil was a rather firm, coarse sand containing many small stones; it had apparently been brought from another area into this region of sand dunes to serve as a base for the road. *Hoplisoides splendidulus* (Bradley) was also nesting close beside the two species of *Cerceris* (Rubink 1977).

Females of both species brought in prey at frequent intervals during the day, carrying the beetles in their mandibles and plunging into open nest entrances. Nests of *C. californica* had the entrance mounds only on one side of the hole, those of *fumipennis* surrounding the hole; otherwise there was no difference in external appearance. Nor was there any noteworthy difference in nest structure. We excavated 3 nests of *californica*. In each case the mound at the entrance measured about 4 x 5 cm, about 1 cm high. The burrow penetrated the soil obliquely or nearly vertically, terminating at a depth of only 8–12 cm, and containing 7–32 beetles in storage near the bottom. One nest had only one cell, the other two five cells each, the cells varying in depth from 7 to 13.5 cm ($\bar{x} = 10$). The number of beetles per cell varied from 7 fairly large ones to 31 very small ones. The two nests of *fumipennis* we excavated were of virtually identical structure. Both had an oblique burrow reaching a depth of 8–9 cm and containing beetles in storage at the terminus. One nest had only one cell, the other 11. Cells varied in depth from 7 to 15 cm ($\bar{x} = 10.2$). The number of beetles per cell varied from 15 to 16 (N = 3; most of the cells had cocoons and only fragments of beetles).

We refrain from further discussion of nesting behavior since both species have been well studied elsewhere, *californica* by Linsley and MacSwain (1956), *fumipennis* by Evans (1971) and several others (references in Scullen and Wold 1969). However, we were especially interested in discovering to what extent females of the two species were competing for prey. Several species of Buprestidae appeared in the nests of both species (Table I). In general, *fumipennis* females took beetles of medium size (5.5–10.5 mm in length). Females of *californica* also took beetles of this same size, but 41 percent of the prey consisted of a minute buprestid, *Acmaeodera quadrivittata* Horn, not utilized by *fumipennis*. However, four other species appeared in the nests of both species.

On several occasions satellite flies, *Senotainia* sp., probably *rubriventris* Macquart, were seen following females carrying prey. Numerous male mutillids flew close above the ground in the morning hours. A number of females were also seen, some of them attempting to enter nests of *C. fumipennis*, though usually being repelled by the resident wasp. The mutillids proved to be males and females of *Dasymutilla snoworum* Cockerell and Fox. We have no definite information that this species is a parasite of *Cerceris*, but the species was common in the nesting area and was not noted elsewhere.

ACKNOWLEDGMENTS

We are indebted to the following specialists for identifying the beetle prey: W. F. Barr(Buprestidae), J. M. Kingsolver (Phalacridae), T. J. Spilman (Tenebrionidae), R. White (Chrysomelidae), and D. R. Whitehead (Curculionidae). R. J. Gagné identified the miltogrammine flies.

LITERATURE CITED

Alcock, J. 1974. The nesting behaviour of *Cerceris simplex macrosticta* (Hymenoptera: Sphecidae). J. Nat. Hist. 8: 645–652.

______. 1975. Social interactions in the solitary wasp *Cerceris simplex* (Hymenoptera: Sphecidae). Behaviour 54: 142–152.

Cartwright, O. L. 1929. The maize billbug in South Carolina (*Calendra maidis* Chittn.). Bull. So. Carolina Agri. Exp. Sta. no. 257: 31 pp.

Evans, H. E. 1971. Observations on the nesting behavior of wasps of the tribe Cercerini. J. Kansas Ent. Soc. 44: 500–523.

______. 1974. Digger wasps as colonizers of new habitat (Hymenoptera: Aculeata). J. N.Y. Ent. Soc. 82: 259–267.

Krombein, K. V. 1953. Kill Devil Hills wasps, 1952 (Hymenoptera: Aculeata). Proc. Ent. Soc. Wash. 55: 113–135.

______. 1960. Biological notes on several southwestern groundnesting wasps (Hymenoptera: Sphecidae). Bull. Brooklyn Ent. Soc. 55: 75–79.

Lin, C. S. 1967. Bionomics of *Cerceris simplex graphica* at Lake Texoma (Hymenoptera: Sphecidae: Philanthinae). Proc. Ent. Soc. Wash. 69: 312–317.

Linsley, E. G. and J. W. MacSwain. 1956. Some observations on the nesting habits and prey of *Cerceris californica* Cresson (Hymenoptera: Sphecidae). Ann. Ent. Soc. Amer. 49: 71–84.

Rau, P. 1928. Field studies in the behavior of the nonsocial wasps. Trans. Acad. Sci. St. Louis 25: 319–489.

Rubink, W. L. 1977. Nesting behavior and prey records of *Hoplisoides splendidulus* (Bradley). Southwestern Ent. 2: 1–3.

Scullen, H. A. 1965. A review of the genus *Cerceris* in America north of Mexico (Hymenoptera: Sphecidae). Proc. U.S. Natl. Mus. 116: 333–547.

Scullen, H. A., and J. L. Wold. 1969. Biology of wasps of the tribe Cercerini, with a list of Coleoptera used as prey. Ann. Ent. Soc. Amer. 62: 209–214.

Strandtmann, R. W. 1945. Observations on the nesting habits of some digger wasps. Ann. Ent. Soc. Amer. 38: 305–313.

Table 1. Prey records for *Cerceris fumipennis* and *C. californica*, Monahans, Texas.

Beetle species	Mean length x width (mm)	Wasp species		Total
		fumipennis	*californica*	
Acmaeodera quadrivittata Horn	6.3	0	51	51
Acmaeodera variegata Leconte	20.3	50	58	108
Agrilus pulchellus Bland	20.7	11	14	25
Chrysobothris (two species)	38.0	1	2	3
Total		62	125	187

VERTEBRATE FAUNA OF A RADIOACTIVE LEACHING POND COMPLEX IN SOUTHEASTERN IDAHO

Douglas K. Halford[1] and Jere B. Millard[2]

Abstract.— An inventory of the terrestrial vertebrate fauna and the seasonal occurrence of each species was determined for a man-made radioactive leaching pond complex in southeastern Idaho. Three reptile, 11 mammal, and 94 bird species were identified from February 1974 through January 1978. Fewest species were observed during the winter and most during the summer. Eight bird species nested at the pond complex, while 19 species of birds were common or seasonally abundant. It appears that the Test Reactor Area radioactive leaching pond complex is an important water source and provides habitat for some species of wildlife.

Since 1952, man-made leaching ponds at the Test Reactor Area (TRA) on the Idaho National Engineering Laboratory (INEL) Site in southeastern Idaho (Fig. 1) have been used to dispose of low-level liquid radioactive wastes generated from various test reactors and their support facilities. A variety of wildlife is attracted to the leaching pond complex which is one of the few sources of water available on or near the INEL Site. The Big Lost River flows intermittently and sometimes crosses as much as 50 km of the southwestern section of the site and then terminates in the Big Lost River Sinks. The Little Lost River terminates in the Little Lost River Sinks east of Howe (Fig. 1) before entering the site. The Big Lost and Little Lost rivers may dry up for a considerable portion of their length during the summer. During the winter they are often frozen. Mud Lake, which is 50 km northeast of the study area, is frozen during much of the winter, as are most other standing bodies of water in the area. However, since the TRA pond complex receives heated effluents, water is available throughout the year.

Since the pond complex contains radioactive isotopes, a potential exists for the movement of radionuclides from the area by indigenous animals. Therefore, it is important to document which species use the pond so estimations can be made on the export of radioactive materials and the potential for radionuclide uptake from species taken and consumed by hunters.

To determine which species of wildlife used the TRA pond complex, a species inventory was conducted. The purpose of this paper is to report species composition, abundance, and seasonal distribution of the vertebrate fauna which occur at the TRA radioactive leaching pond complex. The data from this study will provide information on wildlife attracted to a man-made radioactive leaching pond and also provide a data base for studies being conducted on the pond ecosystem and the environmental impacts if the pond were drained or otherwise altered.

Study Area

The study was conducted at the TRA radioactive leaching pond on the INEL Site, Butte Co. in southeastern Idaho (Fig. 1). The INEL Site covers an area of 2315 km^2. The site is located on the cool desert shrub biome along the western edge of the upper Snake River Plain. The topography is flat to rolling, with an average elevation of 1470 m. The elevation of the study area is 1500 m. Annual precipitation averages 18–20 cm and temperatures range from −42 to 39 C, with an annual average of 6 C. Vegetation is dominated by desert shrubs, primarily big sagebrush (*Artemisia tridentata*), which covers about 80 percent of the site; the under-

---

[1] Environmental Sciences Branch, Idaho National Enginering Laboratory, U.S. Department of Energy, Idaho Falls, Idaho 83401.

[2] Department of Radiology and Radiation Biology, Colorado State University, Fort Collins, Colorado 80521.

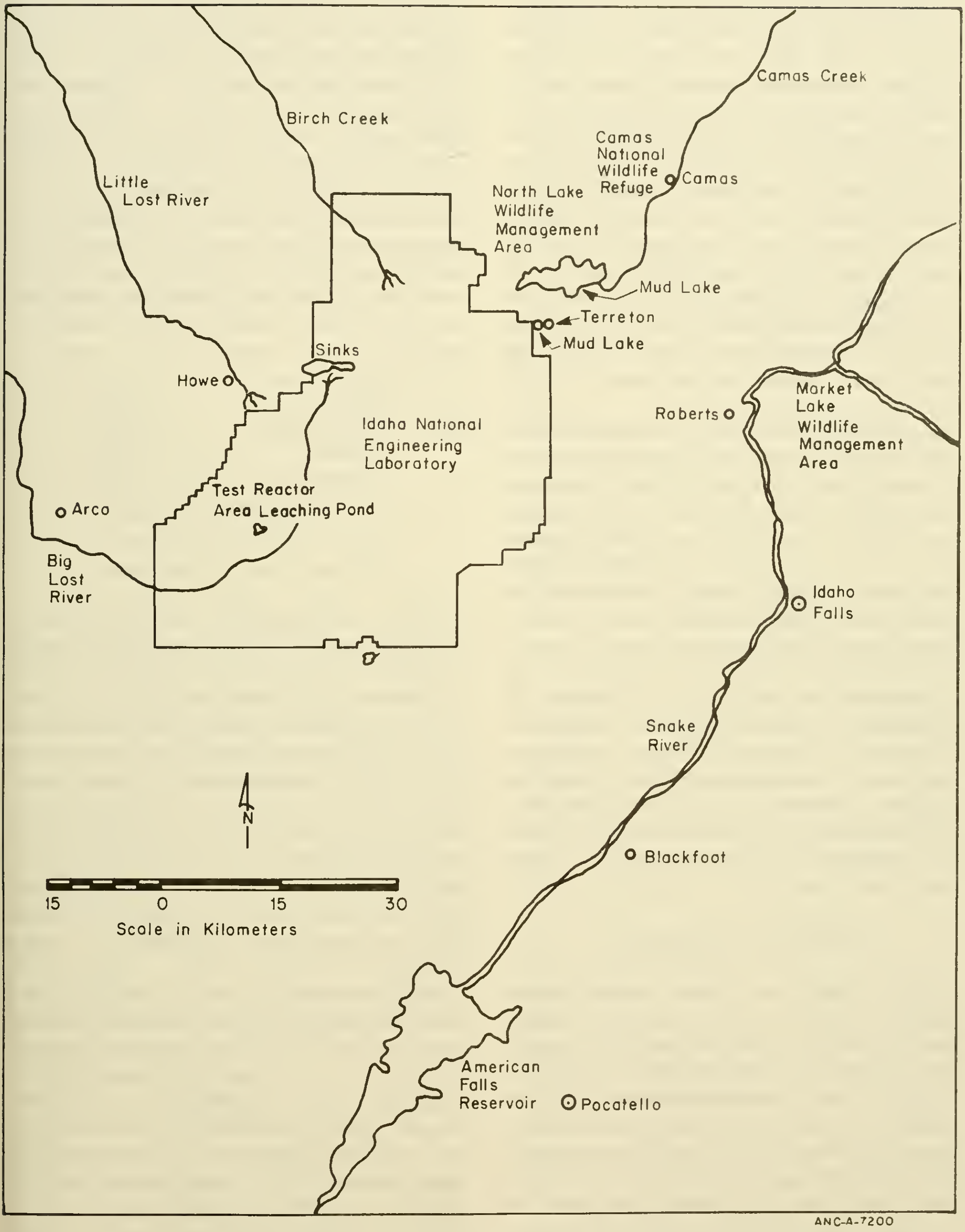

Camas Creek
Birch Creek
Camas National Wildlife Refuge
Camas
Little Lost River
North Lake Wildlife Management Area
Mud Lake
Terreton
Mud Lake
Sinks
Howe
Roberts
Market Lake Wildlife Management Area
Idaho National Engineering Laboratory
Test Reactor Area Leaching Pond
Arco
Big Lost River
Idaho Falls
Snake River
N
Blackfoot
15 0 15 30
Scale in Kilometers
American Falls Reservoir
Pocatello
ANC-A-7200

Fig. 1. Location of Test Reactor Area leaching pond complex on the Idaho National Engineering Laboratory Site in southeastern Idaho.

story is composed of grasses and forbs (Harniss and West 1973).

The leaching pond complex is composed of three ponds excavated in gravelly alluvium in 1952, 1957, and 1964. The low-level liquid radioactive wastes disposed in the ponds percolate in the lithosphere. The ponds constructed in 1952 and 1957 presently constitute one continuous body of water 8200 m^2 in area with a mean depth of 3.0 m. Overflow of water from these ponds enters the adjacent 1964 pond. The 1964 pond is partially covered with shallow water forming a marshy area of about 1250 m^2. A continuous 1.1 m high, 10 cm mesh wire and barbed-wire fence encloses all three ponds, forming a total area of 26,000 m^2.

Aquatic and littoral vegetation associated with disturbed sites have invaded the area. Littoral plants include thistles (*Cirsium arvenes* and *C. vulgare*), speedwell (*Veronica spp.*), wild lettuce (*Lactuca serriola*), cheatgrass (*Bromus tectorum*), wild barley (*Hordeum jubatum*), and willow (*Salix spp.*). The predominant shrub within the fenced area is rabbit brush (*Chrysothamnus nauseosus* and *C. vicidiflorus*). Sedges (*Scirpus spp.*) are the predominant macrophytes. A dense mat of periphyton, composed primarily of diatoms, is present on the pond bottom throughout the year. An autochthonous-based food web supports numerous aquatic arthropods. The vegetation outside of the fenced area consists primarily of big sagebrush, rabbit brush, and cheatgrass.

MATERIALS AND METHODS

Birds, reptiles and large mammals were identified and counted inside the fenced area of the pond complex on 849 observation days from 1 February 1974 to 31 January 1978. Large mammals observed in close proximity to but outside of the fenced area were also listed on the species inventory. Mammal tracks identified inside the pond fence and along the outside perimeter of the fence were recorded as observations.

Observations were made with 8 × 40 binoculars and a 20-power spotting scope between 0800 and 1300 from a vehicle driven around the entire perimeter of the pond area. Small mammals were inventoried by trapping inside the pond fence with 70 Sherman live traps. Rodents were ear-tagged, released, and retrapped from July 1976 through November 1976 and May 1977 through October 1977. Trapping was conducted three consecutive nights weekly. Field guides were used to aid in identification (Burt and Grossenheider 1964, Robbins et al. 1966, Stebbins 1966).

Species abundance was calculated as the percentage of time a species was observed during the total observation period. Species were then placed into arbitrary categories or abundance according to the following criteria:

Rare	≤ 4
Uncommon	5–19
Common	20–39
Abundant	≥ 40
Observed (but not counted)	

RESULTS AND DISCUSSION

Three species of reptiles, 11 species of mammals, and 94 species of birds were identified at the TRA pond complex (Table 1). Although not observed, the prairie rattlesnake (*Crotalus viridis*) and short-horned lizard (*Phrynosaoma douglassii*) were probably present because they are known to occur widely over the site and in habitat similar to that adjacent to the TRA pond complex (Sehman et al. 1976). The only amphibian known to occur on the INEL Site, the Great Basin spadefoot toad (*Scaphiopus intermontanus*), was not observed at the TRA pond complex.

Small mammals trapped at the TRA pond complex were resident animals (Halford and Markham 1978). Evidence of small mammal activity, such as burrows, was present. Since trapping was not continued during the winter, the seasonal distribution of rodents is not complete. However, the species captured and observed during spring, summer, and fall are probably representative of the winter occurrence, although some species hibernate. The most abundant small mammal at the TRA pond complex was the white-footed deer mouse (*Peromyscus maniculatus*) and the least abundant was the meadow vole (*Microtus pennsylvanicus*).

Pronghorn antelope (*Antilocapra americana*) are the most abundant large mammal on the INEL Site and were observed regularly outside the wire perimeter on the TRA complex. On one occasion, 20 antelope were seen feeding on the vegetation around the marshy portion of the pond. These animals apparently entered the pond complex through an improperly closed gate. No drinking by antelope was noted. Mule deer (*Odocoileus hemionus*) were observed drinking and feeding in the TRA pond complex on several occasions and may have relied on the pond as a water source.

Coyotes (*Canis latrans*), the only large predator noted, were seen infrequently. Most identifications were made from tracks or prey remains, usually sage grouse, found inside the fenced area.

A large diversity of birds was observed at the TRA pond complex (Table 1). Of the 94 species identified, 19 were common or abundant seasonally, 19 were sighted once, and 8 nested. Marsh hawks (*Circus cyaneus*), killdeer (*Charadrius vociferus*), spotted sandpipers (*Actitis macularia*), barn swallows (*Hirundo rustica*), and mallards (*Anas platyrhynchos*) nested each year of the study period, and blue-winged teal (*A. discors*), Brewer's blackbirds (*Euphagus cyanocephalus*), and sage thrashers (*Oreoscoptes montanus*) were known to nest but once. Barn swallows were the most abundant nester, building over 20 nests each year in a sewage facility 100 m north of the TRA pond complex. Other uncounted nests were located on buildings associated with the TRA complex. Nest material was obtained from the TRA pond by the swallows. Other species, particularly sage (*Amphisipiza belli*) and Brewer's sparrows (*Spizella breweri*), probably nest in the area.

The most bird species were observed during summer and the least during winter. Spring and fall counts also showed an abundance of birds (Table 2). The Passeriformes was the most frequently represented order, with the highest species counts occurring during spring and summer. Anseriformes was the next most frequently represented order, with most species observed during the spring and fall migration periods. Three of the 15 orders account for more than 75 percent of the species identified (Table 2). The most frequently observed birds were mallards and green-winged teal (*Anas crecca*).

Mourning doves (*Zenaida macroura*), sage grouse (*Centrocercus urophasianus*), and waterfowl were game birds that frequently used the pond. Other species, such as pheasant (*Phasianus colchicus*) and gray partridge (*Perdix perdix*), were observed infrequently (Table 1). Mourning doves appeared to use the pond for drinking water and waterfowl used the pond as a resting area. Sage grouse with broods were observed in early summer, and adult flocks were observed during the fall. Previous studies (Halford et al. 1976, Markham 1976) indicate that doves and waterfowl ingest or become externally contaminated with radionuclides from the TRA pond environs. However, these birds have relatively low concentrations of radionuclide contamination.

Radionuclide concentrations in sage grouse (Jack Connelly, pers. comm. Dec. 1977), barn swallows, marsh hawks, and American kestrels (*Falco sparverius*) were also assessed (Millard et al. 1976, Craig et al. 1978) and found to be low. Since none of the birds inventoried stay at the pond for long periods, it is unlikely that they would accumulate sufficient concentrations of radionuclides to be harmful. Studies are currently being conducted to determine what hazard, if any, the TRA pond complex has on fauna utilizing it.

Craig (1977) found 12 species of raptors present on the INEL Site, although we observed only 4 species at the TRA pond complex. The marsh hawk and American kestrel were the most common species sighted, and both species nested in or near the pond complex. Young marsh hawks and kestrels from these nests had low levels of radionuclides. Nuclides found in nestling raptors were those found in the TRA pond environs, indicating that these birds obtained some prey items from the TRA pond complex (Craig et al. 1978).

This species inventory indicated that the TRA radioactive leaching pond complex may provide a source of food, water, and other habitat requirements for several spe-

TABLE 1. Seasonal occurrence and abundance of reptiles, mammals and birds at the Test Reactor Area leaching ponds in southeastern Idaho.

	Seasonal Occurrence and Abundance			
Species	Spring	Summer	Fall	Winter
REPTILES				
Bull Snake (*Pituophis melanoleucus*)	—	c^{+}	—	—
Western Terrestrial Garter Snake (*Thamnophis elegans*)	—	u	—	—
Sagebrush Lizard (*Sceloporus graciosus*)	—	o	—	—
MAMMALS				
Coyote (*Canis latrans*)	o	o	o	o
Long-tailed Weasel (*Mustela frenata*)	—	o	—	—
Least Chipmunk (*Eutamias minimus*)	c	c	c	—
Ords Kangaroo Rat (*Dipodomys ordii*)	c	c	c	—
Western Harvest Mouse (*Reithrodontomys megalotis*)	u	u	u	—
White-footed Deer Mouse (*Peromyscus maniculatus*)	a	a	a	—
Meadow Vole (*Microtus pennsylvanicus*)	—	r	—	—
Mountain Cottontail (*Sylvilagus nuttalli*)	o	o	o	o
Pygmy Rabbit (*Sylvilagus idahoensis*)	—	o	—	—
Mule Deer (Odocoileus hemionus)	—	u	u	—
Pronghorn (*Antilocapra americana*)	u	c	c	u
BIRDS				
Western Grebe (*Aechmophorus occidentalis*)	—	—	r	—
Eared Grebe (*Podiceps nigricollis*)	u	u	c	u
Pied-billed Grebe (*Podilymbus podiceps*)	u	—	u	—
White Pelican (*Pelecanus erythrorhynchos*)	—	—	r^{++}	—
Whistling Swan (*Olor columbianus*)	r^{++}	—	—	—
Snow goose (*Chen caerulescens*)	—	—	—	r^{++}
Canada goose (*Branta canadensis*)	u	—	u	—
Mallard (*Anas platyrhynchos*)	c	a°	u	a
Pintail (*Anas acuta*)	u	—	r	—
Gadwall (*Anas strepera*)	r	r	r	—
American Wigeon (*Anas americana*)	r	r	u	—
Shoveler (*Anas clypeata*)	u	r	u	—
Blue-winged Teal (*Anas discors*)	u	c°	u	—
Cinnamon Teal (*Anas cyanoptera*)	u	u	—	—
Green-winged Teal (*Anas crecca*)	c	u	a	u
Wood Duck (*Aix sponsa*)	r^{++}	—	—	—
Redhead (*Aythya americana*)	r	—	u	r
Canvasback (*Aythya valisineria*)	—	—	r^{++}	—
Ring-necked Duck (*Aythya collaris*)	—	—	r^{++}	—
Lesser Scaup (*Aythya affinis*)	r	—	c	u
Common Goldeneye (*Bucephala clangula*)	u	—	u	c
Barrow's Goldeneye (*Bucephala islandica*)	—	—	r	—
Bufflehead (*Bucephala albeola*)	u	—	c	—
Ruddy Duck (*Oxyura jamaicensis*)	u	—	u	—
Common Merganser (*Mergus merganser*)	—	u	—	—
American Kestrel (*Falco sparverius*)	—	u	—	—
Marsh Hawk (*Circus cyaneus*)	a°	c	u	—
Swainson's Hawk (*Buteo swainsoni*)	—	r^{++}	—	—
Ferruginous Hawk (*Buteo regalis*)	—	r^{++}	—	—
Sage Grouse (*Centrocercus urophasianus*)	r	u	u	—
Ringneck Pheasant (*Phasianus colchicus*)	—	—	r	—
Gray Partridge (*Perdix perdix*)	r	—	—	—
Great Blue Heron (*Ardea herodias*)	—	r	—	—
Green Heron (*Butorides virescens*)	—	r^{++}	—	—
American Bittern (*Botaurus lentiginosus*)	—	r^{++}	—	—
White-faced Ibis (*Plegadis chihi*)	—	r	—	—
American Coot (*Fulica americana*)	u	r	u	u
American Avocet (*Recurvirostra americana*)	r	u	—	—
Killdeer (*Charadrius vociferus*)	c	c°	u	—

Spotted Sandpiper (*Actitis macularia*)	u	c°	u	—
Solitary Sandpiper (*Tringa solitaria*)	r	r	—	—
Lesser Yellowlegs (*Tringa flavipes*)	—	r++	—	—
Common Snipe (*Capella gallinago*)	—	r++	—	—
Willet (*Catoptrophorus semipalmatus*)	—	r	—	—
Marbled Godwit (*Limosa fedoa*)	—	—	r++	—
Wilson's Phalarope (*Steganopus tricolor*)	u	u	u	—
Herring Gull (*Larus argentatus*)	—	—	r++	—
Ring-billed Gull (*Larus delawarensis*)	—	—	r	—
Bonaparte's Gull (*Larus philadelphia*)	—	—	r	—
Black Tern (*Chlidonias niger*)	—	r++	—	—
Caspian Tern (*Hydroprogne caspia*)	—	—	r++	—
Mourning Dove (*Zenaida macroura*)	u	a	u	r
Great Horned Owl (*Bubo virginianus*)	r	—	—	r
Common Nighthawk (*Chordeiles minor*)	—	u	—	—
Rufous Hummingbird (*Selasphorus rufus*)	—	u	—	—
Belted Kingfisher (*Megaceryle alcyon*)	—	r	u	—
Common Flicker (*Colaptes auratus*)	—	r	r	—
Eastern Kingbird (*Tyrannus tyrannus*)	r	r	—	—
Western Kingbird (*Tyrannus verticalis*)	—	r	—	—
Say's Phoebe (*Sayornis saya*)	u	u	u	—
Horned Lark (*Eremophila alpestris*)	u	a	u	a
Barn Swallow (*Hirundo rustica*)	c	a°	c	—
Cliff Swallow (*Petrochelidon pyrrhonata*)	u	u	—	—
Violet-green Swallow (*Tachycineta thalassina*)	r	u	—	—
Tree Swallow (*Iridoprocne bicolor*)	u	u	—	—
Bank Swallow (*Riparia riparia*)	u	—	—	—
Rough-winged Swallow (*Stelgidopteryx ruficollis*)	c	u	—	—
Black-billed Magpie (*Pica pica*)	u	u	u	u
House Wren (*Troglodytes aedon*)	o	o	—	—
Sage Thrasher (*Oreoscoptes montanus*)	c	c°	—	—
American Robin (*Turdus migratorius*)	r	r	r	—
Ruby-crowned Kinglet (*Regulus calendula*)	r	—	u	—
Loggerhead Shrike (*Lanius ludovicianus*)	r	r	—	—
Starling (*Sturnus vulgaris*)	c	c	u	—
Yellow-rumped Warbler (*Dendroica coronata*)	o	—	o	—
Yellow Warbler (*Dendroica petechia*)	o	—	—	—
Townsend's Warbler (*Dendroica townsendi*)	r++	—	—	—
Western Tanager (*Piranga ludoviciana*)	—	r++	—	—
Western Meadowlark (*Sturnella neglecta*)	u	c	—	—
Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*)	u	u	u	—
Red-winged Blackbird (*Agelaius phoeniceus*)	c	c	c	—
Brewer's Blackbird (*Euphagus cyanocephalus*)	c	c°	c	r
Brown-headed Cowbird (*Molothrus ater*)	—	u	—	—
House Finch (*Carpodacus mexicanus*)	o	o	o	—
Dark-eyed Junco (*Junco hyemalis*)	—	o	o	—
Lapland Longspur (*Calcarius lapponicus*)	—	o	—	—
White-crowned Sparrow (*Zonotrichia leucophrys*)	—	o	o	—
Chipping Sparrow (*Spizella passerina*)	o	o	o	—
Sage Sparrow (*Amphispiza belli*)	c	c	—	—
Lark Sparrow (*Chondestes grammacus*)	—	o	—	—
Song Sparrow (*Melospiza melodia*)	o	o	—	—
Grasshopper Sparrow (*Ammodramus savannarum*)	—	o	o	—
Brewer's Sparrow (*Spizella breweri*)	u	c	—	—
Snow Bunting (*Plectrophenax nivalis*)	—	—	—	r++

+r = rare, c = common, u = uncommon, a = abundant, o = observed (numbers undetermined)
++ Single observation
° Known nester

Table 2. Numbers of bird species by order observed seasonally at the Test Reactor Area radioactive leaching pond complex.

Bird Orders	Number of Species Observed Seasonally Spring	Summer	Fall	Winter	Total Species
Podicipediformes	2	1	3	1	3
Pelecaniformes	0	0	1	0	1
Anseriformes	16	8	16	6	21
Falconiformes	1	4	1	0	4
Galliformes	2	1	2	0	3
Ciconiiformes	0	4	0	0	4
Gruiformes	1	1	1	1	1
Charadriiformes	5	9	8	0	14
Columbiformes	1	1	1	1	1
Strigiformes	1	0	0	1	1
Caprimulgiformes	0	1	0	0	1
Apodiformes	0	1	0	0	1
Coraciiformes	0	1	1	0	1
Piciformes	0	1	1	0	1
Passeriformes	28	31	16	4	37
Totals	57	64	51	13	94

cies of wildlife which may otherwise not be available on the INEL Site. Because the area is protected from public interference, it may also act as a refuge for certain species. The TRA pond complex provides a unique opportunity to study the movement of radionuclides in an ecosystem and the effects of a radioactive environment on indigenous species.

Acknowledgments

We thank B. W. Mortensen for his field assistance and O. D. Markham for critically reviewing the manuscript. Funds for this project were provided by the Division of Biomedical and Environmental Research, U.S. Department of Energy.

Literature Cited

Burt, W. H., and R. P. Grossenheider. 1964. A field guide to the mammals. Houghton Mifflin Co., Boston. 284 pp.

Craig, T. H. 1977. Raptors of the Idaho National Engineering Laboratory Site. Unpubl. master's thesis. Idaho State University, Pocatello.

Craig, T. H., D. K. Halford, and O. D. Markham. 1978. Radionuclide concentrations in nestling raptors near nuclear facilities. Wilson Bulletin (in press).

Halford, D. K., J. B. Millard, and O. D. Markham. 1976. Waterfowl study of the Test Reactor Area radioactive leaching pond, pp. 19–34. *In*: 1975 progress report, Idaho National Engineering Laboratory Site radioecology-ecology programs. IDO-12080. Nat. Tech. Information Service, Springfield, Virginia.

Halford, D. K., and O. D. Markham. 1978. Radiation dosimetry of small mammals inhabiting a liquid radioactive waste disposal area. Ecology (in press).

Harniss, R. O., and N. E. West. 1973. Vegetation patterns of the National Reactor Testing Station, southeastern Idaho. Northwest Sci. 47:30–43.

Markham, O. D. 1976. Gamma emitting isotopes in mourning doves on the INEL site, pp. 58–64 *In*: 1975 progress report, Idaho National Engineering Laboratory Site radioecology-ecology Programs. IDO-12080. Nat. Tech. Information Service, Springfield, Virginia.

Millard, J. B., F. W. Whicker, and O. D. Markham. 1976. An ecological study of the Test Reactor Area radioactive leaching ponds, pp. 17–18. *In*: 1975 progress report, Idaho National Engineering Laboratory Site radioecology-ecology programs. IDO-12080. Nat. Tech. Information Service, Springfield, Virginia.

Robbins, C. S., B. Bruun, H. S. Zim, and A. Singer. 1966. A guide to field identification—birds of North America. Racine, Wisconsin: Western Publ. Co. 340 pp.

Sehman, R. W., A. D. Linder, D. Wyckoff, and W. E. Christopher. 1976. A study of the amphibian and reptilian fauna of the INEL Site, pp. 121–131. *In*: 1975 progress report, Idaho National Engineering Laboratory Site radioecology-ecology programs. IDO-12080. Nat. Tech. Information Service, Springfield, Virginia.

Stebbins, R. C. 1966. A field guide to western reptiles and amphibians. Boston: Houghton Mifflin Co. 279 pp.

NEW SYNONYMY, NEW SPECIES, AND TAXONOMIC NOTES OF NORTH AMERICAN *PITYOPHTHORUS* (COLEOPTERA: SCOLYTIDAE), PART III

Donald E. Bright[1]

Abstract.— New synonymies and new data affecting North American *Pityophthorus* are proposed as follows: *chalcoensis* Hopkins (=*herrerai* Hopkins) and *nigricans* Blandford (=*chiapensis* Bright). Neotypes are designated for the following species described by Eichhoff: *concentralis*, *cribripennis*, *infans*, *puchellus*, and *tuberculatus*. New species are: *carinatus* (Canada), *cavatus* (Manitoba, Saskatchewan), *euterpes* (Mexico), *hesperius* (British Columbia), *impexus* (Mexico), *intentus* (Arizona), *laticeps* (Mexico), *malleatus* (Arizona), *mesembria* (Guatemala), *montezumae* (Mexico), *scalptus* (British Columbia, Colorado), *trepidus* (California), and *vespertinus* (Mexico).

This is the third paper under this general title wherein various new taxonomic data affecting the classification of the North American *Pityophthorus* are proposed.

A taxonomic monograph of North American *Pityophthorus* is being prepared, but the data contained herein is needed for other works in preparation. It was therefore decided to publish these data now in order that they may be used without delay.

The collections where type material is located are abbreviated as follows: British Museum (Natural History), London (BMNH); Canadian National Collection of Insects, Ottawa (CNC); Karl E. Schedl collection, Lienz, Austria (KESC); S. L. Wood collection, Provo, Utah (SLWC), and United States National Museum of Natural History, Washington, D.C. (USNM).

Acknowledgments

Various individuals assisted in this study by loaning specimens, and I wish to express my appreciation to the following: Dr. D. M. Anderson (USNM); Prof. K. E. Schedl, Lienz, Austria; Dr. R. T. Thompson (BMNH); and Dr. S. L. Wood, Provo, Utah. Dr. S. L. Wood also offered valuable comments and opinions concerning the data presented herein.

Pityophthorus chalcoensis Hopkins

Pityophthorus chalcoensis Hopkins, 1905, p. 73 (Holotype ♀, Mexico, USNM)

Pityophthorus herrerai Hopkins, 1905, p. 74 (Holotype ♀, Mexico, USNM). *New synonymy*

This species, and its synonym *herrerai*, until recently have remained unknown since their description. References to neither name were found except for listings of the names in catalogs.

When reading the descriptions of the two species, it seems obvious that two distinct entities are present. *P. chalcoensis* is described as having the second declivital interspace deeply impressed and the first and third declivital interspaces with distinct granules. *P. herrerai* is described as having the second declivital interspace flat, the first declivital interspace with a few irregular granules and the third without distinct granules. With just four specimens of the combined type series of both species to examine, these distinctions can be seen. However, a short series of specimens referred to this species from Hidalgo, Mexico, has also been examined. One female in this series is identical to the female holotype of *chalcoensis*, one male is identical to the male paratype of *herrerai* and another female is very close to the female paratype of *herrerai*. It seems, therefore, that the differences noted by Hopkins are only variations in the species and only one name should be recognized.

The frons of adults of both sexes is almost identical. Both are very broadly flattened and densely pubescent. The only sexual distinction I could detect is the presence of a slightly elevated, impunctate callus at the midpoint of the upper margin of the male frons. Unfortunately, this callus is almost always concealed by the anterior margin of the pronotum and is only visible if the head is fully extended or if the anterior margin of the pronotum is broken away. In addition, adults may be recognized by the lack of a pronotal summit, by the densely punctured posterior portion of the pronotum, by the large strial punctures which form irregular strial rows, and by the steep, bisulcate elytral declivity which usually bears prominent granules on interspaces 1 and 3.

---

[1] Biosystematics Research Institute, Canada Agriculture, Ottawa, Ontario.

Pityophthorus nigricans Blandford

Pityophthorus nigricans Blandford, 1904, p. 236 (Lectotype ♂, Guatemala, BMNH)

Pityophthorus chiapensis Bright, 1977, p. 522 (Holotype ♀, Mexico, CNC). *New synonymy*

The type material of *P. chiapensis* was compared to my homotypes of *P. nigricans* and found to represent the same species. The association of these two names was not apparent until the species described as *P. lepidus* Bright was recognized. A series of *P. lepidus* was previously considered to be *P. nigricans* and is therefore quite different from specimens subsequently described as *P. chiapensis*. At the suggestion of S. L. Wood, the specimens under all the above names were reexamined with the result that *P. chiapensis* must be merged with *P. nigricans*.

Neotype Designations

W. J. Eichhoff, over a period of years between 1868–1878, described a number of species of North American *Pityophthorus*. No original type specimens have been found despite the considerable correspondence with European museums where the types might have been housed. Presumably the specimens were in the Hamburg Museum (where other Eichhoff types were held) when the museum was destroyed during World War II.

Hans Eggers, a noted authority on the Scolytidae, had the opportunity in 1927 of comparing a number of North American species with the types in European museums. The specimens Eggers compared with the types are in the United States Museum of Natural History in Washington, D.C. Compared specimens representing five of Eichhoff's North American *Pityophthorus* have been located. These are listed below, along with notes concerning one additional species. Neotypes are now designated for all of Eichhoff's species of North American *Pityophthorus* except *P. bisulcatus*.

P. concentralis, 1878, p. 188. No specimens bearing Eggers's "compared to type" label have been located. There is a series of four specimens in the USNM that were examined by Eggers and the first of these bears the label "nicht Pityophthorus concentralis Eichh., Eggers 1927." However, Eichhoff himself identified some specimens in 1892 that had been collected in Florida by Hubbard and Schwarz. Eichhoff, in Eichhoff and Schwarz (1895), states "*P. concentralis* from Florida is correctly determined and does not differ in the least from my typical specimen from Cuba. . . ." The specimens sent to Eggers in 1927 were from the same series that was seen by Eichhoff in 1892. Obviously, either Eichhoff or Eggers made a mistake and I am inclined to follow the opinion of Eichhoff, the original describer of *P. concentralis*. Therefore regardless of Eggers's label, in the interest of stability of nomenclaure, I designate the first specimen in the USNM series seen by Eggers as the NEOTYPE. It bears the data: "Biscayne, Fla., 29.5"/"Coll. Hubbard and Schwarz"/"9" (on a white square)/"nicht Pityophthorus concentralis Eichh." (in Eggers's handwriting), Eggers 1927/"NEOTYPE Pityophthorus concentralis Eichh., D. E. Bright 1977."

P. cribripennis, 1869, p. 274. Neotype here designated, bears the data: "Ripley, Mississippi, 4-21-20"/"M.W. Blackman, collector"/"N.Y.S.C.F. Lot Mi 261"/"Pityophthorus cribripennis Eichh. mit type in coll. Eichhoff verglichten" (in Eggers's handwriting)/"NEOTYPE Pityophthorus cribripennis Eichhoff. D. E. Bright 1977." Synonym of *P. pullus* Zimmerman.

P. infans, 1872, p. 135. Neotype, here designated, bears the labels: "Syracuse, N.Y., 5-14-18"/"M.W. Blackman, collector"/"N.Y.S.C.F. Lot 1138"/"compared with type of *P. infans* Eichh. by H. Eggers. Five specimens, all typical" (large red label, handwriting unknown)/"NEOTYPE Pityophthorus infans Eichhoff, D. E. Bright 1977." Synonym of *P. puberulus* Le Conte.

P. pulchellus, 1869, p. 275. Neotype (♀), here designated, is labeled: "Marquette, Mich"/"Coll. Hubbard and Schwarz"/ "♀"/"13"/"Pityophthorus pulchellus Eichh., m. type in coll. Eichhoff verglichen" (in Eggers's handwriting)/ "NEOTYPE Pityophthorus pulchellus Eichhoff, D. E. Bright, 1977."

P. tuberculatus, 1878, p. 498. Neotype (♂), here designated, bears the data: "Hopk. U.S. 471a"/"Black Hills, S.D., Hopkins Colr."/ "Pityophthorus tuberculatus Eichh., m. type in coll. Eichhoff verglichen" (in Eggers's handwriting)/"5"/"NEOTYPE Pityophthorus tuberculatus Eichhoff, D. E. Bright, 1977.")

New Species

Pityophthorus carinatus, n.sp.

Length 1.9–2.2 mm, 3.0 times longer than wide.

Female.— Frons moderately concave on each side of a very strongly elevated, longitudinal carina, this carina sharp to moderately broad on summit, sometimes bearing short setae along summit, the carina usually more strongly elevated on epistomal area and extending to upper level of eyes; concave areas extending laterally nearly to eyes, surface moderately shining near eye, weakly and very finely punctured; an oval patch of extremely short setae forms a "spongy" patch in midarea, this patch extending upward on slopes of elevated carina to summit. Antennal club oval, 1.2–1.3 times longer than wide, widest through segment 2; sutures 1 and 2 weakly arcuate, 2 more strongly so; segments 1 and 2 occupy more than half the total club length.

Pronotum about 1.2 times longer than wide, widest at level of summit; sides subparallel on posterior half; anterior margin broadly rounded, with about a dozen small, basally contiguous serrations; asperities on anterior slope low, small, usually isolated, scattered in no apparent order; summit distinct, high, with transverse impression distinctly indicated; posterior area distinctly punctured, the punctures rather small and shallow, separated by a distance equal to or less than their diameters; interpuncture surface moderately shining and rather densely, minutely reticulate; median line narrow, sometimes weakly elevated on anterior half or less.

Elytra about 1.8 times longer than wide; apex broadly rounded; striae and interstriae with numerous, intermixed punctures, making discernment of striae difficult, but striae are discernible because strial punctures are more numerous and arranged in a regular row, the punctures about equal in size and depth to those on posterior portion of pronotum. Declivity deeply impressed; interspace 1 weakly, narrowly elevated, deeply impressed below level of interspace 3; interspace 2 slightly widened, distinctly sulcate, the lateral portions raising abruptly toward interspace 3; interspace 3 distinctly elevated, much higher than 1, bearing a row of fine granules on summit; punctures in striae 1 and 2 obsolete.

Male.— Frons flattened from eye to eye and from epistoma to upper level of eyes, divided by a strongly elevated, laterally flattened longitudinal carina, this carina more strongly elevated on lower portion on epistomal region; surface of flattened area strongly punctured, the punctures rather long and deep. Pronotum and elytra as in female. Declivity convex; lateral protuberances strongly to weakly elevated, strongly turned or pushed inward toward sutue.

This species occurs in two distinct populations, which are designated as subspecies.

1. Summit of longitudinal, median elevation on female frons sharp, usually devoid of setae; protuberances on male declivity strongly elevated, blunt, extending inward over suture; occurs in NE United States and E Canada .... *P. carinatus carinatus*, n. subsp.

Summit of median elevation on female frons broad, with short setae; protuberances on male declivity not strongly elevated, pushed inward toward suture; occurs in British Columbia and Alberta .... *P. carinatus monticolae*, n. subsp.

Type material.— *P. carinatus carinatus*, n. subsp. Holotype (♀), U.S., New York, Sevey, 8-VIII-1970, D. E. Bright/on Picea/♀/HOLOTYPE *Pityophthorus carinatus carinatus*, D. E. Bright, 1977, CNC No. 15489. Allotype and two paratypes with same data. Nine paratypes are labeled: 64-1340-01, Ex. branch white pine/2 mi. E. of Jemseg, Queen's Co., N.B. 21 May 1965 F.I.S. Paratypes are in the CNC and the SLWC.

P. carinatus monticolae, n. subsp. Holotype (♀) is labeled: No. 70-569-01, Date II.VI-1970, F.I.S./P. contorta, Hazelton, B.C./♀/HOLOTYPE Pityophthorus carinatus monticolae D. E. Bright, CNC No. 15490. Two paratypes bear the same data. Allotype and three paratypes are labeled: Edmonton, Alta., 5-VII-1924/A. T. McClay collection. All type material is in the CNC.

Remarks.— This species represents a very distinctive form that is easily recognized by the very strongly elevated, median carina on the female frons. The area on each side of the median carina is moderately concave and "spongy" on the inner portions and on the carina. In the eastern population the carina is very sharp along the summit and usually not pubescent, while in the western population the carina is broader and pubescent on the summit.

The male declivity of the eastern population resembles that of *P. cariniceps* LeConte, but is more variable in the western series.

This species probably is related to *P. cariniceps* and could conceivably represent an extreme variation of that species. However, no intergrades between *P. carinatus* and *P. cariniceps* have been seen and the size difference seems consistent.

Pityophthorus cavatus, n.sp.

Length 1.9–2.3 mm, 3.0 times longer than wide.

Female.— Frons deeply concave in central area, concavity fringed by a dense brush of erect, coarse setae, central portion of concavity glabrous but may also bear densely placed, erect setae, these setae usually equal in length to those on periphery; an obscure to distinct, laterally flattened, acute tooth is usually present on midpoint of epistoma; surface above and lateral to concavity deeply punctured, the punctures large, close, space between punctures shining. Antennal club nearly round, about as long as wide; suture 1 transverse or very weakly arcuate, 2 more strongly arcuate; segments 1 and 2 occupy more than half the total club length.

Pronotum about 1.3 times longer than wide; sides weakly arcuate; anterior margin broadly rounded, bearing about 10 erect, generally isolated serrations; asperities on anterior slope erect, of moderate size, and scattered in no apparent order; summit distinct; transverse depression behind summit distinct; posterior portion densely punctured, the punctures rather large, deep, and close; interpuncture space moderately shining, reticulate; median line narrow, impunctate.

Elytra about 1.8 times longer than wide; apex broadly rounded; discal striae and interstriae punctured in regular rows, making discernment of striae or interstriae difficult, strial punctures more numerous and each bears a very short seta, interstrial punctures much less numerous and each bears a longer erect seta; surface of interspaces shining, with numerous fine lines or very faintly reticulate. Declivity convex, bisulcate; interspace 1 weakly elevated, impressed below level of 3, devoid of granules; interspace 2 weakly sulcate, slightly wider than discal width, surface as on disc; interspace 3 weakly elevated, higher than 1, bearing a median row of 2–4 small, rounded granules; punctures in striae 1 and 2 obsolete.

Male.— Only two male specimens of this species are known, and each differs considerably from the other in the characters of the declivity.

Variety 1. Frons flattened from upper level of eyes to epistoma, divided by a strongly elevated longitudinal carina, highest at epistoma and slanting downward on upper areas. Pronotum as on female. Elytra as on female except interstrial punctures more numerous and setae slightly longer. Declivity almost evenly convex, with a median, elongate rounded elevation that appears to arise in interspace 2 and is slightly bent inward over interspace 1; interspace 3 not elevated or granulate; surface of declivity moderately shining, minutely reticulate with weak strial punctures.

Variety 2. Frons distinctly impressed from epistoma to near upper level of eyes, divided by a strongly elevated, laterally flattened, toothlike carina; generally similar to variety 1. Pronotum and elytra as in variety 1. Declivity convex; interspace 1 weakly impressed, devoid of granules; interspace 2 weakly sulcate; interspace 3 bearing a large, rounded protuberance in middle of declivity, this protuberance directed caudad, inner slope precipitous, outer slope oblique; surface of declivity as in variety 1.

Type material.— The holotype (♀) and four paratypes were collected at Canoe Lake, Saskatchewan, on 21 July 1972, from branches of *Pinus banksiana*, by D. E. Bright (CNC No. 15492). Six additional paratypes were collected at Charlottetown, Manitoba, on 13 August 1954, from branches of red pine.

The holotype and most of the paratypes are in the CNC. Additional paratypes are in the SLWC.

Remarks.— This is a unique species that can be easily recognized by the characters given in the description. It is obviously a member of the *cariniceps* group, but its relationship to other species is not clear. Some female specimens bear a vague resemblance to some specimens of *P. biovalis* Blackman, but this does not indicate a true relationship to that species.

Pityophthorus euterpes, n. sp.

Length 1.5–1.8 mm, 3.0–3.1 times longer than wide.

Male.— Frons convex, bearing a very faint, longitudinal carina which extends from the weakly elevated epistoma to the upper eye level; surface shining, closely, deeply punctured, the punctures separated by a distance less than half their own diameters; vestiture inconspicuous. Antennal club 1.5 times longer than wide, widest through segment 2; sutures 1 and 2 transverse; segments 1 and 2 occupy about half the total club length.

Pronotum 1.2 times longer than wide, widest at about middle; sides weakly arcuate; anterior margin rather narrowly rounded, bearing about 10 separated serrations; asperities on anterior slope arranged into three distinct, concentric rows, two other indistinct concentric rows at summit, some of those in rows 1 and 2 slightly offset; summit distinctly but weakly elevated; posterior area strongly punctured, the punctures deep, moderately large, separated by a distance equal to about half or less of their diameters; interpuncture space brightly shining, smooth, with scattered fine points; median line broad, scarcely elevated.

Elytra 1.7 times longer than wide; apex broadly rounded, weakly produced at suture; discal striae punctured in regular rows, the punctures rather large, deeply impressed; discal interspaces weakly convex, about 1.5 times wider than striae, the surface shining, impunctate, very finely sculptured with fine lines and points. Declivity deeply sulcate; interspace 1 weakly elevated above 2, bearing a median row of fine setaceous granules; interspace 2 not wider than discal width, smooth to apex; interspace 3 abruptly elevated, much higher than 1, bearing about six prominent, acute granules along summit; punctures of striae 1 and 2 distinct, impressed, somewhat smaller than those on disc. Vestiture mostly confined to declivital region, the setae rather long, fine, and sparse.

Female.— The form suspected to be the female is nearly identical to the male except declivital interspace 3 is much less strongly elevated with much finer granules.

Type material.— The holotype (♂), and five paratypes were collected 21 miles (35 km) west of Lazaro Cardenas, Chiapas, Mexico, on 26 June 1969 from *Pinus oocarpa*, by D. E. Bright (CNC No. 15167). Three additional paratypes were collected at Lagos des Colores (Lagunas de Montebello National Park), Chiapas, Mexico, on 14 June 1969, by D. E. Bright, and one paratype is from Ocosingo Valley, Chiapas, Mexico, collected on 7 July 1960, by Stannard.

The holotype and most of the paratypes are in the CNC; additional paratypes are in the SLWC and the KESC.

Discussion.— This species is closely related to *P. obtusipennis* Blandford, but the adults of *P. euterpes* may be distinguished by their smaller, more slender body and by the finer granules on the declivital interspaces 1 and 3.

Pityophthorus hesperius, n. sp.

Length 2.1–2.3 mm, about 3.0 times longer than wide.

Female.— Frons variable, varying from weakly, longitudinally sulcate in the median area, with the lateral elevations of the sulcus weakly to moderately elevated and spongy, to frons moderately protuberant in median area and spongy over entire surface; a small, laterally flattened tooth is usually located on epistoma of all forms; surface of remainder of frons moderately deeply punctured. Antennal club as in *concavus*.

Pronotum, elytra, and declivity as in *balsameus* and *concavus*.

Male.— Frons flattened from epistoma to upper level of eyes, divided by a small, laterally flattened, distinct carina, the upper margin of flattened area elevated into a transverse, moderately to weakly elevated ridge; surface moderately punctured, shining. Pronotum and elytra as in *balsameus* and *concavus*. Declivity convex; median protuberances arising on interspace 3 pushed inward toward suture or appearing that each interspace 1 is pinched together.

Type material.— The holotype (♀) is labeled: No. 74-1571-01, Date: 21-VIII-74, F.I.S. 1974/P. contorta, Hudson Hope, B.C./Holotype Pityophthorus hesperius D. E. Bright, 1977, (CNC No. 15491). The allotype bears the same data except the date is 3-IX-1974. Paratypes as follows: 3, same as holotype except dated 6-IX-1974; 5, same except dated 21-VIII-74; 1, same except dated 9-IX-1974; 1, same except dated 16-VIII-74; 1, Hixon, B.C., VII-9-1972, D. E. Bright/Pinus contorta; 1, Prince George, B.C., Pinus contorta/No. 72-1143-01, 14-XI-72, F.I.S. 1972; 4, Blackwater R., 21-VIII-57/57-7671-01, Pinus contorta and 1, 57-7672-02, Pinus contorta/158 Mile House, B.C., 15-VIII-57, F.I.S.

The holotype, allotype, and most of the paratypes are in the CNC. Additional paratypes are in the SLWC and the KESC.

Remarks.— This species contains females that resemble both *P. balsameus* Blackman and *P. concavus* Blackman. In the earlier stages of this study I considered it as a subspecies of *P. balsameus*. Wood (pers. comm.) was inclined to associate it with *P. concavus*. A reexamination of the series showed that forms resembling both species were present, even within populations from one locality. After careful consideration, I decided to treat it as a separate species. More collecting is needed, particularly in British Columbia, Alberta, and the adjacent regions to definitely establish its status.

Pityophthorus impexus, n. sp.

Length 1.9–2.1 mm, about 3.1 times longer than wide.

Female.— Frons weakly convex on a large semicircular area extending from epistomal margin to well above upper level of eyes and laterally nearly from eye to eye; surface shining, bearing large, deep punctures on periphery, these becoming smaller toward middle, median portion weakly flattened and impunctate on a small area just above epistomal margin; vestiture rather sparse, consisting of long, erect setae scattered over the surface, those on periphery somewhat longer and incurved. Antennal club large, about 1.2 times longer than wide, widest through segment 3; segment 1 small, narrower than 2 or 3; suture 1 weakly arcuate, 2 more stronglly so; segments 1 and 2 occupy less than half the total club length.

Pronotum 1.1 times or less longer than wide; sides weakly arcuate on basal half; anterior margin broadly rounded, bearing about 6 to 8 distinct serrations, these gradually increasing in size toward middle; asperities on anterior slope moderately large, erect, usually isolated but 2 or 3 occasionally basally contiguous; summit distinct, high; posterior portion densely punctured, the punctures large and deeply impressed, separated by a distance equal to about half their diameters; interpuncture surface moderately shining, rather densely microreticulate; median line broad, not elevated, narrowed just behind summit.

Elytra 1.7 times longer than wide; apex broadly rounded; striae punctured in regular rows, the punctures about equal in size to those on posterior portion of pronotum, rather deeply impressed; discal interspaces about 1.0 to 1.5 times wider than striae, impunctate (except 1), surface moderately shining, densely microreticulate. Declivity convex, somewhat flattened between the third interspaces; interspace 1 equal in width to its discal width, slightly elevated, bearing a median row of very fine granules and short setae; interspace 2 flat, as wide as discal width, very weakly impressed below level of 1 and 3; interspace 3 very weakly elevated, equal in height to 1, bearing a median row of fine granules and long setae, the granules slightly larger than those in 1, and the setae much longer; remaining alternate interspaces bear long setae on posterior third (or less) of elytra; punctures in striae 1 and 2 distinct, smaller than those on disc.

Male.— Frons convex, narrowly, transversely impressed just above epistoma; this impression divided by a median, longitudinal, laterally flattened, small tooth; surface of frons rather densely pubescent and deeply, closely punctured, the punctures smaller and finer in transverse impression. Pronotum as in female except asperities and serrations larger. Elytra essentially as in female.

Type material.— The holotype (♀), allotype, and nine paratypes were collected 6 miles (10 km) south of Carapan, Michoacon, Mexico on 18 June 1965 from *Pinus* sp., by S. L. Wood. Five additional paratypes were collected 3 miles (5 km) west of El Salto, Durango, Mexico, on 17 June 1965 from twigs of *Pinus ayacahuite* by S. L. Wood, and two paratypes were collected by R. Coronado P. at Tequesquinahua, Mexico, Mexico, on 2 March 1962, from twigs of a *Pinus* sp.

The holotype, allotype, and most of the paratypes are in the SLWC. A pair of paratypes is in the CNC (No. 15480).

Remarks.— Adults of this species resemble closely those of *P. segnis* Blackman and *P. subopacus* Blackman. The adults of *P. impexus* differ from the latter species by the more flattened, more weakly impressed elytral declivity, especially between the third interspaces of each elytron, by the more densely pubescent male frons and the more sharply elevated longitudinal carina and by the more extensive pubescent area on the female frons.

Pityophthorus intentus, n. sp.

Length 1.5–1.8 mm, about 2.8 times longer than wide.

Female.— Frons weakly convex, flattened or weakly, transversely impressed from epistoma to near upper level of eyes, with a weak, longitudinal carina which extends from the epistoma to upper level of eyes, ending at a weakly elevated, impunctate, median elevation; surface deeply, densely punctured, the punctures rather large and close, almost touching; vestiture sparse, scattered and inconspicuous. Antennal club small, oval, about 1.4 times longer than wide; sutures 1 and 2 straight; segments 1 and 2 occupy more than half the total club length.

Pronotum 1.1 times longer than wide; sides nearly straight, parallel on basal half; anterior margin broadly rounded, bearing about a dozen very low, basally contiguous serrations; asperities on anterior slope erect, low, generally isolated and arranged in no apparent order; summit distinct; posterior portion finely punctured, the punctures shallow, small, and usually separated by distances greater than their diameters; interpuncture space brightly shining, generally smooth but usually bearing a few very minute points or lines; median line narrow, not clearly evident.

Elytra about 1.9 times longer than wide; apex strongly acuminate; striae punctured in regular rows, the punctures much larger than those on posterior portion of pronotum, deeply impressed; discal interspaces about as wide as striae or slightly narrower, surface moderately shining, with scattered fine points and lines. Declivity bisulcate; interspace 1 narrowly, strongly elevated, equal in height to 3, bearing a median row of about four widely separated, acute granules and erect, stout setae; interspace 2 deeply sulcate, distinctly wider than discal width, smooth and shining; interspace 3 distinctly elevated and bearing a median row of about four widely separated, acute granules, these equal in size to those on interspace 1; punctures in striae 1 and 2 obsolete.

MALE.— Frons almost identical to female except median transverse elevation stronger, longitudinal carina slightly more evident and punctures on surface slightly stronger. Pronotum and elytra as in female except elytral apex less strongly acuminate. Declivity essentially as in female except interspace 2 slightly less deeply impressed and interstrial setae stouter.

TYPE MATERIAL.— The holotype (♀), allotype, and 11 paratypes were collected in Bear Canyon, Santa Catalina Mountains, Arizona, on 15 August 1968, from twigs of *Pinus ponderosa*, by D. E. Bright (CNC No. 15481). Five additional paratypes are from the Santa Rita Mountains, Santa Cruz Co., Arizona, collected on 29 July 1968, from *Pinus strobiformis* (1) and *Pseudotsuga menziesii* (4), by D. E. Bright.

The holotype, allotype, and most of the paratypes are in the CNC; additional paratypes are in the SLWC and the KESC.

REMARKS.— Adults of *P. intentus* resemble those of *P. consimilis* LeConte but differ in a number of points. On adults of *P. intentus*, the second declivital interspace is more deeply sulcate, the granules on declivital interspaces 1 and 3 are much larger, the punctures on the frons of both sexes are larger and deeper, and the longitudinal carina and the transverse elevation are much more prominent. In addition, *P. consimilis* occurs in conifers in eastern North America, and *P. intentus* occurs in conifers in the southwestern United States.

Pityophthorus laticeps, n. sp.

Length 2.5 mm about 2.9 times longer than wide.

MALE.— Frons flattened from epistoma to well above eyes, very weakly impressed in median portion, divided by a proiminent but weakly elevated longitudinal carina which extends from epistomal margin to well above upper level of eyes; surface moderately shining, rather strongly punctured, the punctures distinctly impressed, close, separated by a distance equal to or less than their diameters; vestiture short but conspicuous and abundant. Antennal club oval, 1.3 times longer than wide; sutures 1 and 2 very weakly arcuate; segments 1 and 2 occupy more than half the total club length.

Pronotum 1.1 times longer than wide, widest at about middle; sides weakly arcuate; anterior margin broadly rounded, with about 10 contiguous, rather large serrations; asperities on anterior slope erect, rather large, isolated, scattered in no readily apparent order; summit distinct; posterior area distinctly punctured, the punctures of moderate size, usually separated by a distance more than their own diameters; interpuncture space moderately shining, with numerous very fine micropoints; median line broad, impunctate.

Elytra 1.6 to 1.7 times longer than wide; apex broadly rounded; discal striae punctured in regular rows, the punctures large, almost touching, deeply impressed; discal interspaces about 2.0 times wider than striae, surface brightly shining, densely micropunctate and subrugulose, interspaces 1, 3, 5, 7, and 9 each bearing on disc a median row of about 3 to 4 larger setose punctures, these punctures as large and deep as those in striae, the setae arising from these punctures rather long and stout. Declivity broadly flattened between the fourth interspaces; interspace 1 rather deeply impressed below level of 3 on upper half, slightly elevated above surface at apex, bearing a median row of very fine granules and short setae; interspace 2 broadly sulcate, slightly wider than discal width, bearing 2 or 3 very small, acute granules at top; interspace 3 weakly elevated on upper half, bearing about 5 rounded granules on the upper portion and 1 or 2 more at apex, each granule bearing a moderately long, stout seta; interspaces 4 and 5 smooth, bearing a median row of fine setae; punctures of striae 1 large, not impressed, those in striae 2 much smaller in median area of declivital face than those on disc, those at apex nearly as large as those on disc.

FEMALE.— Not definitely recognized in material at hand. A female bearing the identical data and apparently associated with the male has the following characteristics: Frons broadly flattened on a large semicircular area, densely pubescent, with the peripheral setae longer and incurved. Pronotum essentially as in male holotype except interpuncture spaces on posterior portion are more densely micropunctate/reticulate and the large punctures are larger and deeper. Elytra essentially as in male except strial punctures slightly smaller and shallower. Declivity completely different from male, convex, not flattened; interspace 1 slightly impressed below level of 3, bearing a median row of fine granules; interspace 2 weakly, not broadly sulcate, only slightly wider than discal width; interspace 3 weakly elevated, distinctly higher than 1, bearing a median row of moderately large, rounded, setose granules; strial punctures as in male holotype.

Type material.— The holotype (♂) was collected 20.5 km. north of Oaxaca, Oaxaca, Mexico, at an elevation of 9000 feet, on 6 June 1971, from *Pinus* sp., by D. E. Bright (CNC No. 15482). The female specimen described above bears the same data but is not designated as an allotype.

Remarks.— Males of this species are readily distinguished by the broadly flattened elytral declivity in which interspace 3 is near the middle of the declivital face and is granulate only on the upper half and again at the apex, and by the finely punctured posterior half of the pronotum which, in the interpuncture spaces, bears dense, fine micropoints.

The female associated with the male specimen resembles the male in several features but I have doubts that it is the actual female of this species. Until more specimens are available, the female must remain doubtful.

Pityophthorus malleatus, n. sp.

Length 1.9–2.2 mm, about 2.9 times longer than wide.

Female.— Frons flattened from epistoma to above upper level of eye and laterally occupying about 73 percent of distance between eyes; surface of flattened area densely, moderately, and somewhat roughly punctured except on a small, median area just above epistomal margin, and clothed with sparse, moderately long, fine setae, those on periphery of flattened area slightly longer and incurved; surface lateral to and above flattened area smooth, with large, deep, widely separated punctures. Antennal club oval, 1.4 times longer than wide; sutures 1 and 2 transverse; segments 1 and 2 occupy slightly more than half the total club length.

Pronotum about 1.2 times longer than wide; widest just before level of summit; sides straight, parallel on basal half; anterior margin broadly rounded, bearing about 10 or more, broad, prominent, basally contiguous serrations; asperities on anterior slope rather large and distinct, scattered in no apparent order; summit distinct; posterior portion moderately strongly punctured, the punctures rather large, deep and usually separated by a distance greater than their diameters; interpuncture space brightly shining, smooth, with numerous, minute points.

Elytra about 1.7 times longer than wide; apex broadly rounded; striae punctured in even, regular rows, the punctures quite large and deeply impressed; discal interspaces about 2.0 times wider than striae, surface brightly shining, smooth, impunctate and usually with numerous, scattered, very minute points. Declivity steep and weakly, broadly bisulcate; interspace 1 moderately elevated, surface more opaque than on disc, bearing a median row of about four widely separated granules; interspace 2 moderately sulcate, distinctly wider than discal width, surface dull, opaque, marked with numerous fine lines; interspace 3 moderately elevated, about equal in height to 1, bearing about four or more widely separated granules, these granules about equal in size to those on interspace 1; punctures in striae 1 and 2 obsolete; setae on interspaces 1 and 3 slender, moderately long.

Male.— Frons shallowly, transversely impressed, upper margin of impression bearing a distinct, arcuate, transverse carina; surface below carina densely, deeply punctured except on a very weakly indicated, longitudinal carina; surface above transverse carina more deeply punctured. Antennal club as in female. Pronotum and elytra essentially as in female except sculpturing slightly stronger. Declivity as in female except interspace 2 more deeply impressed, interspace 3 more abruptly elevated, granules on interspaces 1 and 3 slightly larger and setae on interspaces 1 and 3 stouter.

Type material.— The holotype (♀), allotype, and 6 paratypes were collected at Walker, Yavapai County, Arizona, on 23 August 1968, from twigs of *Pseudotsuga menziesii*, by D. E. Bright (CNC No. 15483).

The holotype, allotype, and four paratypes are in the CNC and two paratypes are in the SLWC.

Remarks.— Adults of this species closely resemble those of *P. pseudotsugae* Swaine, but the elytral interspaces of *P. malleatus* are completely impunctate while in *P. pseudotsugae* they bear at least a few setose punctures. In addition, the male frons of *P. malleatus* is less deeply impressed and the setae on the female frons are much sparser and shorter.

In declivital characters, adults of *P. malleatus* also resemble those of *P. intextus* Swaine and *P. cascoensis* Blackman. Females and males of *P. malleatus* differ in the characteristics of the frons and by the impunctate elytral interspaces.

Pityophthorus mesembria, n. sp.

Length 2.0–2.2 mm, about 2.8 times longer than wide.

Female.— Frons flattened on a large semicircular area extending from epistomal margin to well above eyes and laterally occupying over 80 percent of distance between eyes; surface shining, moderately densely punctured, largely concealed by the long, incurved setae which extend from periphery of flattened area almost to epistomal margin, setae on remainder of flattened area very short, erect. Antennal club oval, about 1.3 times longer than wide, widest through segment 2; sutures 1 and 2 transverse, rather heavily chitinized at lateral margins; segments 1 and 2 occupy more than half the total club length.

Pronotum 1.1 times longer than wide, widest on posterior half; sides moderately to rather strongly arcuate; anterior margin narrowly rounded, bearing 10 or more erect, basally contiguous serrations of moderate size; asperities on anterior slope erect, usually isolated but some may be basally contiguous, scattered in no apparent order; summit prominent; transverse impression behind summit distinctly impressed, divided by the distinct, narrowly elevated median line; posterior area strongly punctured, the punctures of moderate size, deeply impressed, separated by a distance equal to or less than their diameters; interpuncture space brightly shining, with numerous fine points.

Elytra 1.6–1.7 times longer than wide; apex moderately acuminate; discal striae punctured in regular rows, the punctures slightly larger than those on posterior portion of pronotum and more deeply impressed, each puncture bearing a very short, recumbent seta; discal interspaces 1.5–2.0 times wider than striae, surface shining, impunctate, smooth with numerous very fine lines and/or points. Declivity shallowly bisulcate; interspace 1 weakly elevated, bearing a median row of 10 or more small, rounded granules, each of these with a longer, erect, moderately stout seta arising from posterior margin; interspace 2 wider than its discal width, shallowly impressed, surface shining, with numerous, scattered, fine points and lines; interspaces 3 slightly elevated, higher than 1, bearing a median row of 8–10 fine, rounded granules, each of these with a stout, erect seta as those on interspace 1; punctures in striae 1 and 2 visible but smaller and less deeply impressed than those on disc.

Male.— Frons flattened on a semicircular area as in female, punctures on this area very large, deep and close; a weakly elevated median, longitudinal carina extends from epistoma to upper level of eyes; vestiture moderately long, sparse, and relatively inconspicuous. Pronotum as in female except asperities larger and the points in the interpuncture spaces on the posterior portion of the pronotum deeper and more conspicuous, resulting in the large punctures becoming more obscure. Elytra as in female except strial punctures deeper. Declivity as in female except granules on interspaces 1 and 3 larger.

Type material.— The holotype (♀), allotype, and five paratypes were collected on Cerro Calel, Quezaltenango, Guatemala, at an elevation of 10,000 feet, on 26 May 1964, from *Abies guatemalensis*, by S. L. Wood.

The holotype, allotype, and three paratypes are in the SLWC; one pair of paratypes is in the CNC (No. 15484).

Remarks.— Adults of this species are distinguished from other species in the *confertus* group by the arcuate pronotal sides, by the densely punctured interpuncture space on the posterior portion of the pronotum, by the presence of numerous granules on declivital interspaces 1 and 3, by the host, and by the distribution.

Pityophthorus montezumae, n. sp.

Length 2.5–2.9 mm, about 2.5–2.6 times longer than wide.

Female.— Frons flattened on a broad area extending from the epistoma to well above upper eye level and laterally nearly from eye to eye, central portion of flattened area frequently concave; surface moderately shining, densely, finely punctured and marked with numerous fine lines and points; vestiture abundant, those setae in central area short and erect, those on periphery much longer and incurved. Antennal club very large, broad, about 1.1 times longer than wide, widest through segment 3; sutures 1 and 2 distinctly arcuate; segment 1 small, much narrower than 2 or 3; segments 1 and 2 together occupy less than half the total club length.

Pronotum as long as wide, widest on posterior one-quarter; sides weakly arcuate to weakly converging; anterior margin broadly rounded, bearing about 10 low, contiguous serrations; asperities on anterior slope numerous, low, broad, densely scattered in no apparent order; summit distinct; transverse impression behind summit moderately impressed; posterior area densely punctured, the punctures moderately deeply impressed and separated by a distance equal to slightly less than their diameters, the lateral margins of some punctures weakly elevated, giving a weakly, subasperate appearance to the surface, especially on lateral areas; interpuncture space dull, finely, minutely reticulate; median line broad, not elevated, impunctate.

Elytra 1.6–1.7 times longer than wide; apex broadly rounded; discal striae punctured in regular rows, the punctures very large, moderately deep and separated by a distance equal to less than half their diameters; discal interspaces narrower than or equal in width to striae, surface moderately dull, densely, minutely reticulate, each interspace with a median row of large punctures equal in size to those in striae, each of these bearing a moderately long, erect seta, the setae longer on posterior portions of each interspace. Declivity convex, moderately bisulcate; interspace 1 moderately elevated, equal in height to 3 or very slightly lower, bearing a median row of about six widely separated, fine granules, each granule with a long, erect seta arising from lower edge; interspace 2 moderately sulcate, equal in width or slightly wider than discal width, surface as on disc; interspace 3 weakly elevated, bearing a median row of about six or less small granules, these slightly larger than those on interspace 1 and each bearing a long erect seta on lower edge; punctures of striae 1 and 2 obsolete.

Male.— Frons flattened to very weakly impressed on each side of a sharply elevated, longitudinal carina extending from epistomal margin to upper level of eyes, this carina more strongly elevated on lower half and sometimes nearly toothlike; surface on each side of carina dull, densely punctured, and with numerous moderately long setae. Pronotum and elytra essentially as in female. Declivity as in female except granules on interspaces 1 and 3 slightly larger.

Type material.— The holotype (♀), allotype, and 22 paratypes were collected 7 miles (11.5 km) east of San Cristobal (de las Casas), Chiapas, on 13 May 1969, from twigs of *Pinus montezumae*, by D. E. Bright (CNC No. 15485). One additional paratype is from 4 miles (6.5 km) east of San Cristobal, Chiapas, collected on 26 May 1969, from *Pinus* sp., by D. E. Bright.

The holotype, allotype, and most of the paratypes are in the CNC. Additional paratypes are in the SLWC and the KESC.

Remarks.— Adults of this species show many of the characteristics of the *blandus* group except for the remarkable antennal club and the more distinctly elevated carina on the male frons. Adults are easily recognized by the very large, broad, antennal club with the narrow first segment and the strongly arcuate sutures, by the sharply elevated but not toothlike carina on the male frons, by the first and third declivital interspaces being nearly equal in height, and by the distribution. This is the only species in this group that occurs south of the Isthmus of Tehuantepec.

Pityophthorus scalptus, n. sp.

Length 2.6–3.0 mm, about 2.7 times longer than wide.

Female.— Frons broadly flattened from eye to eye and from epistoma to well above eyes, slightly but distinctly concave on an almost circular, broad, median area; surface moderately shining, with close, deep, moderately large punctures, and bearing short, erect setae over most of the area, the setae on the periphery being much longer, coarser, and incurved. Antennal club oval, about 1.3 times longer than wide, widest through segment 3; suture 1 nearly transverse, 2 weakly arcuate; segments 1 and 2 occupy less than half the total club length.

Pronotum as long as wide, widest on posterior half; sides moderately arcuate; anterior margin broadly rounded, with about 10 prominent, basally contiguous serrations, the median pair usually quite large and erect; asperities on anterior slope generally large and erect, usually isolated but several may be basally contiguous, scattered in no apparent order; summit distinct; posterior area deeply, closely punctured, the punctures of moderate size, separted by a distance about equal to their diameters, the lateral margin of each puncture elevated into a distinct granule, giving a definite granulate appearance to the posterior surface, these granules usually larger and more distinct posteriorally and laterally to the summit; interpuncture space moderately shining to dull, bearing minute points or minute reticulations; median line broad, surface smooth, impunctate and usually shining.

Elytra 1.5–1.6 times longer than wide; apex broadly rounded; discal striae punctured in regular rows, the punctures small, deep and close, each bearing a minute, erect seta; discal interspaces 2–3 times wider than striae, surface moderately shining, microrugulose or smooth, with numerous fine points and microreticulation; interspaces 1, 3, 5, and 7 each with a few scattered, median punctures, each of which bears a minute, erect seta, each seta equal in length to those in striae. Declivity broadly convex, weakly impressed; interspace 1 narrowly elevated, weakly impressed below level of 3, bearing a median row of close, fine granules; interspace 2 flat, about as wide as on disc, surface as on disc; interspace 3 not elevated, bearing a median row of extremely fine granules; interspace 9 weakly elevated, joining interspace 3 near elytral apex; punctures in striae 1 and 2 distinct, much smaller than those on disc, striae 1 moderately, narrowly impressed.

Male.— Frons broadly, shallowly impressed below upper level of eyes, with a distinct, longitudinal carina extending from the epistoma to above upper eye level; surface moderately shining, densely, closely punctured. Antennal club narrower than in female. Pronotum and elytra essentially as in female. Declivity essentially as in female except interspace 3 very slightly elevated, granules in interspaces 1 and 3 slightly larger, and junction of interspace 3 and 9 slightly more distinct.

Type material.— The holotype (♀), allotype, and 142 paratypes were collected at Aspen Grove, British Columbia, from *Pinus ponderosa*, by H. Richmond on various dates during July 1931 (CNC No. 15486). Two additional paratypes were collected at Estes Park, Colorado, on 31 August 1938 from *Pinus ponderosa* (Hopk. US 31541-V). Four additional specimens, not designated as paratypes, are from Stevensville, Montana, collected on 31 August 1967, from *Pinus ponderosa*, by R. McEwan and M. McGregor (Hopk. US 51945) (USNM).

The holotype, allotype, and 10 paratypes are in the CNC, 10 paratypes are in the SLWC, two are in the KESC, two in the USNM, and the remainder are in the CASC and in the University of British Columbia, Vancouver.

Remarks.— This species is very closely related to *P. scalptor* Blackman. The most obvious and easily seen character which will distinguish the two species is the presence of prominent granules on the posterior portion of the pronotum of adults of *P. scalptus* vs. the absence of granules on adults of *P. scalptor.* Other less obvious differences that distinguish adults of *P. scalptus* are the larger and deeper punctures on the female frons, the slightly lower carina on the male frons, and the slightly smaller size of the antennal club.

Pityophthorus trepidus, n. sp.

Length 1.6–2.0 mm, about 2.7 times longer than wide.

Female.— Frons generally flattened from well above eyes to epistomal margin and from eye to eye, very weakly transversely impressed at midlevel; sometimes a very weak, longitudinal carina is present; surface densely, closely punctured, the punctures deep, distinct, separated by a distance equal to less than their diameters, surface between punctures smooth, shining; vestiture scattered, consisting of moderately long, erect setae. Antennal club oval, about 1.4 times longer than wide, widest through segment 2; sutures 1 and 2 arcuate, 1 slightly more than 2; segments 1 and 2 occupy more than half the total club length.

Pronotum about as long as wide, widest just behind middle; sides broadly arcuate; anterior margin broadly rounded, bearing about a dozen, basally contiguous, erect serrations; asperities on anterior slope erect, of moderate size, scattered in no apparent order; summit distinctly elevated, transverse impression behind summit weak; posterior portion deeply, densely punctured, the punctures rather large, separated by distances equal to less than their diameters; interpuncture space brightly shining, smooth.

Elytra about 1.8 times longer than wide; apex broadly rounded; discal striae punctured in regular rows, the punctures shallow and indistinct, somewhat obscured by the microrugulose sculpturing of surface, each puncture bearing a very short, erect seta; discal interspaces about 2.0 times wider than striae, surface roughened by microrugulose sculpturing, interspaces 1, 3, 5, 7, etc., each bearing a few, scattered, median punctures, each of which bears a very short, erect seta, these setae equal in length to those arising from strial punctures or only slightly longer. Declivity convex, weakly impressed along suture; interspace 1 narrow, bearing a median row of extremely minute granules; interspace 2 wider than discal width, otherwise as on disc; interspace 3 essentially as on disc, bearing a few, very fine granules; punctures in striae 1 and 2 obsolete, striae 1 narrowly, weakly impressed.

Male.— Almost identical to female except longitudinal carina on frons may be more evident. Distinguishable with certainty only by abdominal segmentation.

Type material.— The holotype (♀), allotype, and nine paratypes were collected at Ukiah, California, from *Pinus radiata*, under Hopkins No. 20976. No date or collector is indicated on the specimens.

The holotype, allotype, and five paratypes are in the USNM. Two paratypes each are in the CNC (No. 15487) and the SLWC.

Remarks.— This species is closely related to *P. keeni* (Blackman), but the adults of *P. trepidus* can be distinguished by the very short interstrial setae (equal in length to the strial setae) and by striae 1 being weakly impressed on the declivity. The host relationships also are different, because *P. keeni* is found in various species of pinyon pines in the west and *P. trepidus* is known from *Pinus radiata*, a tree restricted to the coastal and island forests of central southern California.

Pityophthorus vespertinus, n. sp.

Length 1.9–2.0 mm, 2.4–2.5 times longer than wide.

Female.— Frons weakly flattened on a semicircular area extending from epistoma to slightly above upper level of eyes; surface shining, densely, minutely punctured, and clothed with erect, moderately long, yellowish setae. Antennal club nearly circular, widest through segment 3; segment 1 distinctly narrower than others; sutures 1 and 2 arcuate, 2 more strongly so; segments 1 and 2 occupy slightly less than half the total club length.

Pronotum about 1.1 times longer than

wide, widest at posterior angles; sides broadly, weakly arcuate; anterior margin broadly rounded, bearing about 10 small to large serrations, these very low and broad laterally, gradually increasing in size toward middle; asperities on anterior slope small, erect, scattered in no apparent order; summit prominent; posterior area bearing large, shallow, close punctures, these separated by a distance equal to or slightly less than their diameters; interpuncture space dull, densely, minutely reticulate; median line impunctate, weakly elevated.

Elytra about 1.6 times longer than wide; apex broadly rounded; discal striae punctured in fairly regular rows, the punctures rather large, deep and close; discal interspaces about 1.5–2.0 times wider than striae, generally impunctate but sometimes bearing a few, widely separated punctures, surface opaque, densely, minutely reticulate. Declivity convex, very weakly impressed; interspace 1 weakly elevated, with a median row of fine granules; interspace 2 as wide as discal width, weakly impressed; interspace 3 weakly elevated, about equal in height to 1, bearing a median row of fine granules; punctures in striae 1 and 2 distinct, nearly equal in size and depth to those on disc.

MALE.— Frons weakly concave or flattened on each side of a distinctly elevated, longitudinal carina which extends from epistomal margin to near upper level of eyes; surface on each side of carina densely punctured, the punctures large and shallow. Otherwise similar to female.

TYPE MATERIAL.— The holotype (♀), allotype, and two paratypes were collected 23 miles (35 km) west of Durango, Durango, Mexico, 6000 feet in elevation, on 4 June 1965, from twigs of *Pinus* sp., by S. L. Wood.

The holotype, allotype, and one paratype are in the SLWC; one paratype is in the CNC (No. 15488).

REMARKS.— This species is very closely related to *P. diglyphus* Blandford and may eventually prove to be a subspecies or may even be the same species. This species is only known from Durango, Mexico, and *P. diglyphus* is known from quite a few localities in southern Mexico and Guatemala. Because of the wide geographical separation and the morphological differences, I have described *P. vespertinus* as a distinct species.

Adults of *P. vespertinus* are distinguished from those of *P. diglyphus* by the less strongly elevated carina on the male frons, by the less strongly elevated third and ninth elytral interspaces, by the nearly circular antennal club, and by the more northerly distribution.

LITERATURE CITED

BLACKMAN, M. W. 1928. The genus *Pityophthorus* Eichh. in North America: a revisional study of the Pithyophthorini, with descriptions of two new general and seventy-one new species. Bull. New York St. Coll. Forestry, Tech Bull. 25, 159 pp.

BLANDFORD, W. F. H. 1895–1907. Fam. Scolytidae. *In*: Biologia Centrali-Americana 4(6): 81–298.

BRIGHT, D. E. 1977. New synonymy, new combinations, and new species of North American *Pityophthorus* (Coleoptera: Scolytidae). Part I. Canadian Ent. 109: 511–532.

EICHHOFF, W. J. 1869. Neue Borkenkäfer. Berl. ent. Zeitschr. 12: 273–282.

______. 1872. Neue exotische Tomiciden-Arten. Berl. ent. Zeitschr. 15: 131–136.

______. 1878. Ratio, description, emandatio, eorum tomicinorum. Preprint of Mém. Soc. Roy. Sci. Liége, Ser. 2, Vol. 8, 531 pp.

EICHHOFF, W. J. AND E. A. SCHWARZ. 1895. Remarks on the synonymy of some North American scolytid beetles. Proc. U.S. Natn. Mus. 18(1085):605–610.

HOPKINS, A. D. 1905. Notes on some Mexican Scolytidae, with descriptions of some new species. Preprint of Proc. Ent. Soc. Wash. 7(2–3):71–81.

FLUCTUATION OF A MARSH HABITAT AND THE REPRODUCTIVE STRATEGY OF THE YELLOW-HEADED BLACKBIRD

Roger J. Lederer[1]

ABSTRACT.— The Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*) nests in marshes and is dependent on emergent vegetation for nest sites. Fluctuating water levels from year to year cause an increase or decrease in the amount of emergent vegetation and affect the time required for the vegetation to become suitable for nesting. Nests built in marshes are very susceptible to wind, rainfall, vegetation growth, and predation. Many nests are abandoned before being used and the mortality of eggs and young is high. The reproductive strategy of the Yellow-headed Blackbird has been selected for flexibility and opportunism to compensate for the unpredictability of the marsh situation.

Fluctuations in the physical environment can often cause dramatic changes in the local population sizes or reproductive strategies of organisms. The more potential the environment has for short-term change, the more flexible the resident-organisms must be. The marsh-nesting Yellow-headed Blackbird (*Xanthocephalus xanthocephalus*), whose breeding ecology and behavior has been extensively studied by Willson and Orians (1963), Willson (1966), and Orians and Christman (1968), is an organism that clearly demonstrates this flexibility. This study describes the fluctuation in some reproductive characteristics of a population of Yellow-headed Blackbirds in a marsh habitat over a six-year period and expands an earlier report (Lederer et al. 1975).

STUDY AREA AND METHODS

The study area is a marsh 500 m north of the Eagle Lake Field Station on the eastern shore of Eagle Lake, Lassen Co., California. The marsh is dependent on Eagle Lake for its water; a rising water table formed the marsh in 1968 (R. Ediger, pers. comm.).

This study was conducted from mid-May to late July from 1972 to 1977, inclusive. The marsh was censused for adult birds, nests, eggs, and young at least five times per week by walking about transects 25 m apart. Each nest was plotted on a map of the study area, marked with a numbered tag, and the number of eggs and/or nestlings in it was recorded. Observations of the movements of the adult males and aggressive encounters between males were used to determine territorial boundaries. The size of the female population was estimated from the number of active nests and counting of adults. At the peak of the breeding period the surface area and depth of the marsh were measured. Weekly measurements of emergent vegetation height and density were made in several areas around the marsh.

Relationships between variables listed in Table 1 (Dimensions of marsh habitat) and Table 2 (Population and nesting data) were tested with linear regression or linear correlation analysis.

RESULTS

PHYSICAL DIMENSIONS OF THE MARSH.— Table 1 shows that the marsh increased in size and average depth each year from 1972 through 1975, but decreased in both dimensions in 1976 and 1977.

ADULT POPULATION AND TERRITORY SIZE.— Over the six years both the adult population and the number of territories showed an increase. Territory sizes varied. The only significant ($p < .05$) relationship found was a positive relationship between the surface area of the marsh and territory size.

---

[1] Department of Biological Sciences, California State Universiy, Chico, California 95929.

The sex ratio was very consistent over the years, being 2.95 to 3.10 females to males ($\bar{x} = 3.03 \pm .07$).

NESTS, CLUTCH SIZES, AND FLEDGLINGS.— Active nests (many built were never used) produced a low mean of .03 fledged young per nest in 1977 to 1.70 in 1974. There is a significant ($p<.01$) negative correlation between the number of active nests and the average number fledged per active nest. There is also a significant ($p<.05$) negative correlation between the total number of nests and the average number of young fledged per active nest; and the ratio of active/total nests is significantly ($p<.005$) negatively correlated with the average number fledged per active nest. If the number of young fledged per active nest is the criterion of success, then 1974 was the most successful year.

SIZE OF MARSH AND FLEDGING SUCCESS.— There is a significant ($p<.05$) positive correlation between the surface area of the marsh and the number of fledglings per adult.

MORTALITY.— Known causes of mortality of eggs and young were abandonment, toppling into water, and predation by the raccoons (*Procyon lotor*) and coyote (*Canis latrans*). Weather-related mortality was apparent in 1974 when heavy rains occurred, and severe storms in 1975 and 1976 destroyed large numbers of nests which contained eggs or young. Willson (1966) reported similar results. Mortality of fledglings is not known but may be at least 50 percent (Ricklefs 1973). There was extensive raccoon predation in 1977.

DISCUSSION

NEST SITES.— The number of Yellow-headed Blackbirds nesting in a habitat is strongly influenced by the adequacy of nest sites (Immelmann 1972, Willson 1966). Nests were placed in emergent vegetation about .3 m above the water and encompassed 8-70 stalks of *Scirpus* sp. (bulrush) and/or *Juncus* sp. (rush). Because *Scirpus* stalks are thicker and taller than those of *Juncus*, only 10–20 stalks of *Scirpus* could support a nest, but 30–50 stalks of *Juncus* were required. Often, both species were incorporated into the nest and its support. *Scirpus* and *Juncus* grew in shallower water and thus emerged and were available for nesting before *Scirpus*. But *Juncus* frequently proved to be too weak or too sparse, and the nests collapsed or were torn apart as the vegetation grew or the water level changed. Ellarson (1950) and Stevens (1937) (IN: Willson 1966) reported Yellow-headed

TABLE 1. Dimensions of marsh habitat.

	1972	1973	1974	1975	1976	1977
Surface area (hectares)	3.9	4.0	5.3	13.4	8.2	2.5
Average depth (meters)	1.1	.98	1.3	1.6	.8	.43

TABLE 2. Yellow-headed Blackbird population and nesting data.

	1972	1973	1974	1975	1976	1977
Adult population	25	85	83	71	137	202
Number of territories	8	28	28	24	44	66
Minimum-maximum territory sizes (m^2)	not measured	40-101	40-150	804-1500	20-225	7-188
Active nests	8	29	19	53	93	290
Empty nests	0	67	110	58	66	30
Total nests	8	96	129	111	159	320
Ratio of active/total nests	1	.30	.15	.48	.58	.90
Average clutch size	3.0	3.0	2.7	2.6	2.8	2.5
Fledged young	unknown	47	32	63	90	10
Averaged fledged per active nest	unknown	.6	1.7	1.2	.9	.03

Blackbird populations decreasing as the water rose or fell during the season. Later in the season, *Juncus* was more suitable for nesting.

Annual fluctuation of water levels in the marsh affected the time of emergence and density of the emergent vegetation. If the water level was higher than in the previous years (e.g., 1975), the littoral area of marsh had little or no emergent vegetation since it did not have sufficient time to become established. Most of the emergent vegetation was in the deeper part of the marsh and had to grow longer before it emerged, resulting in a later nesting season. Conversely, if the marsh decreased in size from the previous year, much of what was the littoral zone became dry land and no longer supported emergents. A smaller marsh also meant a shallower one, which allowed all the emergent vegetation to emerge sooner and thus provide for an earlier nesting season.

Territories.— The changes in territory size suggest that the territories may have changed in quality with respect to nest sites and/or food (Schoener 1968, Stenger 1958, Willson 1966). Territory sizes indirectly regulate the number of nests that are built because each territorial male will have 2–5 females nesting in his territory (Willson 1966).

Nesting success.— Nesting success is typically measured as the percent of eggs which produce fledglings (Lack 1966, Ricklefs 1969). Using this criterion, the fewer the total number of nests built by the Yellow-headed Blackbird population, the greater was the success of the active nests. The assumption is that if fewer nests are built, more energy can be devoted to each nest. Also, a low ratio of active nests to total nests is closely correlated to nest success. Thus it appears that the optimum situation for nesting success is a low number of total nests with a low proportion of them being active. But why are so many never-to-be-used nests built?

To imply that the birds actively strive to create this set of circumstances would hint at group selection, which I will not invoke as an explanation. An individual male, seeking to attract as many females as possible, will attempt to establish as large a territory as it can defend and include in it as much vegetation edge as possible because females tend to be found in territories with more edge (Willson 1966). An individual female will begin to build a nest as soon as the vegetation can support a nest, but this early nesting leads to many abandoned or damaged nests. The weather is unstable early in the nesting season; storms and cold weather can damage or destroy the nests, eggs, or young. Or the nest may be made unusable by the growth of the vegetation in which it was built. The result is that many nests are abandoned and the female builds another elsewhere in the marsh. Orian's (1961) study of Red-winged and Tricolored Blackbirds demonstrated a high mortality of eggs and young, plus nest desertion. Based on the average sex ratio and the total number of nests, I estimate that each Yellow-headed Blackbird female builds two nests. The effect is that many more nests are built than are actually used. Although later nests are more likely to be used than earlier ones, they too suffer high losses.

Explanations for the negative correlations between numbers of active nests and total numbers of nests with the success of the active nests are offered here. A lower number of total nests implies that either (1) there were fewer breeding adults or (2) fewer nests were destroyed and replaced by another nest, both signifying less stringent breeding conditions. A lower number of active nests means fewer breeding adults competing. The negative correlation between a low ratio of active/total nests and fledging success can be explained by the movement of some breeding adults out of the marsh after their first breeding attempt. After most of the nests were built and incubation was well along in the active nests, the adult population declined. They apparently moved to areas along the edge of Eagle Lake which are considerably deeper (up to 5 m) and do not become suitable for nesting until mid-July, when the vegetation has emerged. Snelling (1968) found a similar drop in Red-winged Blackbird breeding populations. By this time, the marsh vegetation has grown to its maximal height. A survey of the lake's shoreline revealed that the blackbirds began to build nests at about the time hatching was occurring in the marsh.

PHYSICAL DIMENSIONS OF THE MARSH AND MORTALITY.— Predation becomes an important factor when the water level is low. The vast majority of losses of active nests in 1977 were due to raccoon predation because the average water level (.43 m) was so low that raccoons had easy access to the nesting areas. Although high water levels are disadvantageous in that they delay the nesting season, low water levels can be extremely detrimental by allowing terrestrial predators access.

Ricklefs's (1969) work on the nesting mortality of birds states that (1) marsh (and prairie) nesting birds have the highest mortality and (2) the major cause of this mortality is predation due to nest accessibility. Starvation rates are also higher than other birds because fields and marshes have more variable food supplies.

CONCLUSIONS

The data seem to imply that the reproductive strategy of Yellow-headed Blackbirds is inefficient in time and energy. But the situation reported here is probably typical, because the average numbers fledged for all nests were similar to that reported by Willson (1966).

The fact that the marsh becomes a suitable nesting habitat at least a month earlier than other nearby areas, inducing the birds to attempt to nest, probably explains the numerous unused nests. Nest, egg, and young mortality were all high, but some adults were able to bring one or two young to fledging. But whether or not the first nesting was successful, the opportunity to renest in the marsh or in a newly opened habitat was still available. Selection would favor those individuals which attempted to breed in an unstable environmental situation because attempting to nest early (with an apparently tenuous commitment) is probably not much riskier than self-maintenance while waiting for other areas to become suitable; the possibility of bringing off one or two young with only a slight additional risk to the individual bird would confer a selective advantage on those individuals. Additionally, since there is no guarantee that sufficient suitable nest sites will develop later, there are selection pressures against those individuals who wait, as well as for those which nest early.

ACKNOWLEDGMENTS

I would like to thank G. Brown, K. Bumgarner, and T. Tam for considerable field assistance. Parts of this study were funded by a National Science Foundation undergraduate research participation grant awarded to the Eagle Lake Field Station of California State University, Chico.

LITERATURE CITED

BEST, L. B. 1977. Territory quality and mating success in the field Sparrow (Spizella pusilla). Condor 79:192–204.

IMMELMAN, K. 1972. Role of the environment in reproduction. IN: D. S. Farner (ed). Symposium on Breeding Behavior and Reproductive Physiology in Birds, pp. 121–157.

LACK, D. 1966. Population studies of birds. London, Great Britain: Oxford University Press.

LEDERER, R. J., W. S. MAZEN, AND P. J. METROPULOS. 1975. Population fluctuation in a Yellow-headed Blackbird marsh. West. Birds 6:1–6.

ORIANS, G. H. 1961. The ecology of blackbird (*Agelaius*) social systems. Ecol. Monogr. 31:285–312.

ORIANS, G. H. AND G. M. CHRISTMAN. 1968. A comparative study of the behavior of Red-winged, Tricolored, and Yellow-headed Blackbirds. Univ. Calif. Publ. Zool. 84:1–85.

RICKLEFS, R. E. 1972. Fecundity, mortality, and avian demography. IN: D. S. Farner (ed.). Symposium on Breeding Behavior and Reproductive Physiology in Birds, pp. 366–434.

SCHOENER, T. W. 1968. Sizes of feeding territories among birds. Ecology 49:123–141.

SNELLING, J. C. 1968. Overlap in feeding habits of Redwinged Blackbirds and Common Grackles nesting in a cattail marsh. Auk 85:560–585.

STENGER, J. 1958. Food habits and available food of ovenbirds in relation to territory size. Auk 75:335–346.

WILLSON, M. F. 1966. Breeding ecology of the Yellow-headed Blackbird. Ecol. Monogr. 36:51–77.

WILLSON, M. F. AND G. H. ORIANS. 1963. Comparative ecology of Redwinged and Yellow-headed Blackbirds during the breeding season. (abstr.) Proc. XVI. Internat. Cong. Zool. 3:342–346.

HOSTS OF JUNIPER MISTLETOE AT WALNUT CANYON NATIONAL MONUMENT, ARIZONA

Frank G. Hawksworth[1] and Robert L. Mathiasen[2]

Abstract.— Four species of junipers, *Juniperus osteosperma*, *J. scopulorum*, *J. monosperma*, and *J. deppeana*, occur in mixed stands at Walnut Canyon National Monument, Arizona. All are parasitized by *Phoradendron juniperinum*, but the mistletoe was most common on *J. osteosperma* and least common on *J. scopulorum*. Fernbush (*Chamaebatiaria millefolium*, Rosaceae) was a very rare host.

Phoradendron juniperinum Engelm. ex A. Gray parasitizes several species of southwestern junipers (Hedgcock 1915), but no information has been published on the relative susceptibility of its various hosts. The Walnut Canyon National Monument Area, southeast of Flagstaff, Arizona, presents a unique area for host studies as four species of junipers occur together in mixed stands: Utah juniper (*Juniperus osteosperma* (Torr.) Little), Rocky Mountain juniper (*J. scopulorum* Sarg.), one-seed juniper (*J. monosperma* [Engelm.] Sar.), and alligator juniper (*J. deppeana* Steud.).

Stands in the vicinity of Monument Headquarters, the Rim Trail, and the Island Trail were studied and each juniper over three meters high was examined for mistletoe. In all, 282 junipers of the four species were examined.

Mistletoe was most common on *Juniperus osteosperma* as nearly two-thirds of the trees examined were infected. Perhaps this is because *J. osteosperma* is the largest of four junipers in this area, and birds which disseminate the mistletoe tend to prefer taller trees. *Juniperus scopulorum* had the least mistletoe. Infection of *J. monosperma* was intermediate, and too few *J. deppeana* trees were present to evaluate its susceptibility in this area.

Phoradendron juniperinum was found once on fernbush (*Chamaebatiaria millefolium* (Torr.) Maxim., Rosaceae) near the Monument Headquarters. Fernbush has also been reported to be a very rare host for this mistletoe at Grand Canyon National Park (Hawksworth 1952).

Acknowledgment

Thanks are expressed to Mr. James Bailey, National Park Service, Walnut Canyon National Monument, for assistance in this study.

Literature Cited

Hawksworth, G. F. 1952. Unusual hosts for two southwestern mistletoes.

Hedgcock, G. G. 1915. Some notes on tree diseases in our national forests. Phytopathology 5:175–181.

Table 1. Name of this table.

Host	Trees examined No.	Trees with *Phoradendron juniperinum* Percent
J. osteosperma	78	64
J. deppeana	6	50
J. monosperma	125	44
J. scopulorum	73	22

---

[1] U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, Colorado State University, Fort Collins, Colorado 80521.

[2] Department of Plant Pathology, University of Arizona, Tucson, Arizona 85721.

ALLELOPATHIC EFFECTS OF BUR BUTTERCUP TISSUE ON GERMINATION AND GROWTH OF VARIOUS GRASSES AND FORBS *IN VITRO* AND IN SOIL[1]

Bruce A. Buchanan,[2] K. T. Harper,[2]
and
Neil C. Frischknecht[3]

Abstract.— The allelopathic effects of bur buttercup (*Ranunculus testiculatus*) tissue on selected grasses and forbs varied according to the substratum for germination and growth. The *in vitro* effects of an aqueous extract of buttercup tissue on germination and root development of five grasses were strongly inhibitory in all cases. However, in soil the effects of buttercup tissue on germination and growth of seven grasses and two dicotyledonous herbs were small to nonsignificant. Deleterious effects were less severe in fine- as opposed to coarse-textured soils. Under field conditions, the ability of seedlings of the grasses to compete with buttercup varied with the species.

Bur buttercup (*Ranunculus testiculatus* Crantz), a native of southeastern Europe and central Asia (Benson 1948, Davis 1965) was first collected in North America by A. O. Garrett near Salt Lake City, Utah, in 1932. Since that time, the species has spread throughout the Great Basin, the Snake River Plain, and the Columbia Plateau. In much of that area, the species exists in large populations in native vegetation and waste places of the semiarid zone. Small, isolated populations are also known from northeastern Wyoming, northern Arizona, northern California, and interior British Columbia (Buchanan 1969).

The species is a diminutive annual (averaging ca. 5 cm in height) that completes its life cycle during the early spring. In northern Utah germination occurs in late fall, but at more northerly latitudes, germination may be postponed until spring (Buchanan 1969). Despite its small size, the species often forms a dense carpet over literally thousands of acres of dry farm and range land during the period from March to May in the eastern Great Basin.

The invasion of bur buttercup into North America prompted an early interest in its potential as a weed. Two memoranda in the files of the Intermountain Forest and Range Experiment Station (IFRES) of the U.S. Department of Agriculture (Ogden, Utah) report early observations of bur buttercup in Utah and consider its potential as a weed (Clark 1941, and Stewart 1941). The memos, dated 18 July and 3 September 1941, respectively, discuss the plant's history, spread, importance as a weed, and possible control in the West. However, when our study began in 1966, no aspect of the dispersal or ecology of the species had been reported in the scientific literature (exclusive of floras) of North America.

Because of rapid spread of bur buttercup and the dearth of information concerning the species, the Intermountain Forest and Range Experiment Station initiated a program to investigate its life history, ecology, and distribution. Concern over possible deleterious effects of bur buttercup on winter wheat crops and on range grass seedings prompted this study of the competitive and allelopathic effects of bur buttercup on wheat and on grasses used in range revegetation. Germination studies using both glass and soil systems were utilized so that results might be extrapolated to field situations.

---

[1] Research supported under contract 12-11-204-30 between the Intermountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, Ogden, Utah, and the University of Utah.

[2] Department of Biology, University of Utah, Salt Lake City, Utah 84112. Current address of Buchanan is Department of Agronomy, New Mexico State University, Las Cruces, 88003. Current address of Harper is Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602.

[3] Intermountain Forest and Range Experiment Station, Provo, Utah 84601.

METHODS

In vitro studies in petri dishes compared the effect of a leachate from bur buttercup tissue with both distilled water and mannitol as media for germination and root development of five grasses.

The leachate was prepared by soaking one part of air-dried whole plant tissue at fruiting state in 30 parts distilled water at room temperature for 24 hours. The air-dried tissue was first ground through 40-mesh screen. Following soaking, the leachate was filtered through #2 filter paper and stored at 1 C until used. The leachate had an osmotic concentration (O.C.) of 1.8 atmospheres and a pH of 5.5.

Seeds of crested wheatgrass (*Agropyron desertorum*), tall wheatgrass (*A. elongatum*), common rye (*Secale cereale*), Delmar fall wheat (*Triticum aestivum*), and Gaines fall wheat (*T. aestivum*) were each subjected to 6 treatments as follows:

Treatment No.	Wetting Agent	O.C. of Agent (Atm.)	pH of Agent	Effect Tested
1	Distilled H_2O (buffered)	0.0	7.0	Control
2	Distilled H_2O	0.0	5.5	pH
3	Mannitol in H_2O	1.8	7.0	Osmotic pressure
4	Mannitol in H_2O	1.8	5.5	Osmotic pressure and pH
5	Leachate	1.8	7.0	Leachate (pH adjusted)
6	Leachate	1.8	5.5	Leachate

Two pieces of filter paper were placed in each petri dish and 25 seeds were positioned thereon in five rows of five seeds each. Each treatment was replicated 10 times. Dishes were initially wetted with 6 ml of treatment solution. Thereafter, dishes were rewatered daily with 2 ml of distilled water for the duration of the experiment.

At the end of the third-to-seventh day (depending on species), percent germination was recorded. Seeds were considered germinated if a root of 5 mm or longer had emerged from the seed coat. Root length data were taken by randomly selecting two rows (10 seeds) from each petri dish and recording length of all roots.

In addition to *in vitro* studies, the inhibitory effects of bur buttercup were tested on seven grasses and three forbs in potted silty clay soil. This study involved two levels of bur buttercup tissue mixed with soil in undrained pots: average annual field production of bur buttercup (0.7g/dm², 1X) and twice average annual field production of bur buttercup (2X). The study was designed for twelve species, three treatments (control and two levels of tissue), and nine replicates per treatment. Only ten species or varieties were used, but two species (Gaines wheat and crested wheatgrass) appear twice in the design, the second time in sand. The design was a 3 × 3 trimultiple latin square for each species (Cochran and Cox 1957). Sixteen seeds were planted in each pot by pressing seeds through a template to insure uniform spacing (four seeds per row in four rows).

The silty clay soil (15 percent sand, 43 percent silt, and 42 percent clay) used in this experiment was taken from the top 15 cm of a pasture on the Benmore Experimental Range not infested with bur buttercup. The soil was air dried and passed through a 2 mm sieve before potting. Soil pH was 7.5. A layer of sand (about 1 cm deep) was placed over the soil to reduce crusting. A sand (90 percent sand, 5 percent silt, and 5 percent clay), pH 8.0, was likewise dried, screened, and potted as a second substratum for Gaines wheat and crested wheatgrass. The sand was taken from a stream channel at the Benmore Range.

Plastic pots were filled with 625 g of soil (or 955 g of sand) and topped with 80 g of sand. The experiment was conducted in a greenhouse at the University of Utah. Species and substrata are listed below.

Species	Substratum
Bur buttercup	Soil
Fairway wheatgrass (*Agropyron cristatum*)	"
Halogeton (*Halogeton glomeratus*)	"
Alfalfa (*Medicago sativa*)	"
Delmar wheat (*Triticum aestivum*)	"

Tall wheatgrass (*A. elongatum*)	"
Crested wheatgrass (*A. desertorum*)	"
Gaines wheat (*T. aestivum*)	"
Common rye (*Secale cereale*)	"
Western wheatgrass (*A. smithii*)	"
Gaines wheat	Sand
Crested wheatgrass	"

The grasses are all often sown in areas infested with buttercup, halogeton is an introduced annual often associated with bur buttercup in the eastern Great Basin, and alfalfa is a perennial frequently seeded in areas supporting dense stands of buttercup.

On 13 January, all pots were watered with distilled water to water-holding capacity (WHC) and thereafter to WHC when the soil became noticeably dry.

Number of seeds germinated was recorded after 5, 7, 10, 13, 15, 17, 25, and 28 days from the initial wetting of the pots. Beginning on day 34 and continuing through day 40, the species were clipped, oven dried, and weighed. All replications and treatments of a species were harvested on the same day.

Another soil system tested the influence of buttercup on yield of each of 9 grasses sown in the same rows with buttercup, in a cold frame at Benmore. On 5 October, 100 seeds of each grass were planted in each of three rows 150 cm long. Rows planted to the same grass were spaced 2 dm apart, while 4 dm separated rows between species. Fifty and 100 bur buttercup seeds were planted with the grass in the second and third rows, respectively. The first row assigned to each grass species was maintained as a control. Grasses tested were: crested wheatgrass, Fairway wheatgrass, Russian wildrye (*Elymus junceus*), pubescent wheatgrass (*Agropyron trichophorum*), intermediate wheatgrass (*A. intermedium*), western wheatgrass, common rye, Delmar wheat, and Gaines wheat.

Rows were watered 5 October, at planting, and again the following day by rain. Thereafter, lids of the cold frame were closed (except for periodic waterings) until early April. All plants were clipped on 27 and 28 April. Each row was clipped in 15 segments, each 1 dm long. Tissue was bagged and taken immediately to the University of Utah laboratory for drying. Samples were dried at 32 C and weighed. To reduce edge effect from the walls of the cold frame, clipping segments 1 and 15 were not used for determination of the mean production per segment.

RESULTS

In vitro studies in petri dishes indicate that a compound(s) inhibitory to germination and growth of the five species or varieties tested is produced by bur buttercup tissue or the products of its decay (Table 1).

TABLE 1. Effect of six treatments on germination and root development of two grasses and three cereal grains *in vitro.*[*]

		Treatment					
		Control Buffered	Control Acidified	Mannitol	Mannitol Acidified	Leachate pH Adjustment	Leachate
		pH–Osmotic Concentration					
Species	Growth Time (days)	7.0–0.0	5.5–0.0	7.0–0.0	5.5–1.8	7.0–1.8	5.5–1.8
		Percent Germination					
Crested wheatgrass	7	83^{a}	92^{ab}	90^{ab}	93^{b}	0^{c}	0^{c}
Tall wheatgrass	5	85^{a}	87^{a}	81^{a}	82^{a}	0^{b}	0^{b}
Common rye	3	72^{a}	72^{a}	71^{a}	73^{a}	7^{b}	9^{b}
Delmar fall wheat	4	83^{a}	81^{a}	78^{a}	80^{a}	12^{b}	9^{b}
Gaines fall wheat	3	96	96^{a}	94^{a}	95^{a}	24^{b}	16^{b}
		Root Length (mm)					
Crested wheatgrass	7	29^{ab}	25^{a}	31^{ab}	37^{b}	0^{c}	0^{c}
Tall wheatgrass	5	26^{a}	22^{b}	19^{b}	22^{b}	0^{c}	0^{c}
Common rye	3	75^{a}	63^{a}	84^{a}	80^{a}	8^{b}	11^{b}
Delmar fall wheat	4	62^{a}	57^{a}	66^{a}	67^{a}	9^{b}	7^{b}
Gaines fall wheat	3	92^{ab}	76^{a}	86^{ab}	100^{b}	10^{c}	13^{c}

[*] Means for a given species followed by the same letter, in superscript, do not differ at the 1 percent probability level (t-test).

Acidic distilled water had no significant effect on germination, but tended to decrease root length of all species below control levels, although observed differences were not usually significant. At the level tested, osmotic concentration also appeared not to influence germination of these species.

The *in vivo* study in which buttercup tissue was applied to soil in pots showed a different response than was obtained in petri dishes (Table 2). In soil, buttercup tissue significantly retarded germination of only one species, crested wheatgrass. This effect was observed only at the 2X concentration of buttercup tissue. In no case was average weight of individual test plants significantly different than that of control plants.

In sand, germination of crested wheatgrass and Gaines fall wheat was significantly reduced by both 1X and 2X concentration of buttercup tissue (Table 2 and Fig. 1). Average weight of surviving plants of crested

Table 2. Effect of two levels of bur buttercup tissue on germination and dry matter production of seven grasses and two forbs planted in soil or sand. Treatments are: C, control (no tissue added); 1X, tissue added equivalent to average production of buttercup per unit area in pastures (0.7 g/dm^2), and 2X, tissue added equivalent to twice average production of buttercup.

				Days after Planting				
Species	Growth Medium	Treatment	Average Weight per Individual (g)	5	10	15	25	28
				Percent Germination				
Halogeton	Soil	C	[1]	3[2]	9	13	12	12
		1X		3	8	15	10	10
		2X		1	6	13	14	14
Western wheatgrass	Soil	C	0.16	0	3	35	65	67
		1X	0.23	0	11	45	61	61
		2X	0.23	0	3	51	71	71
Fairway wheatgrass	Soil	C	0.36	4	21	56	67	67
		1X	0.32	4	36	53	58	58
		2X	0.36	3	42	53	60	60
Tall wheatgrass	Soil	C	0.30	3	44	89	94	94
		1X	0.34	2	62	89	90	90
		2X	0.34	0	57	80	87	87
Crested wheatgrass	Soil	C	0.23	3	38	81	87	89^{a}
		1X	0.27	13	58	76	80	80^{ab}
		2X	0.28	1	37	62	65	65^{b}
Alfalfa	Soil	C	0.36	23	41	69	71	71
		1X	0.32	21	46	62	64	64
		2X	0.36	15	50	71	71	71
Common rye	Soil	C	0.24	8	19	19	19	19
		1X	0.32	17	26	27	27	27
		2X	0.24	12	24	25	25	25
Delmar fall wheat	Soil	C	0.38	3	21	36	37	37
		1X	0.41	6	34	49	49	49
		2X	0.42	14	35	42	42	42
Gaines fall wheat	Soil	C	0.39	15	44	53	53	54
		1X	0.42	27	53	57	57	57
		2X	0.43	25	59	62	62	62
Crested wheatgrass	Sand	C	0.20^{a}	45^{a}	90^{a}	94^{a}	94^{a}	94^{a}
		1X	0.20^{a}	3^{b}	67^{b}	76^{b}	76^{a}	76^{a}
		2X	0.11^{b}	0^{b}	24^{c}	39^{c}	41^{b}	41^{b}
Gaines fall wheat	Sand	C	[3]	94^{a}	96^{a}	96^{a}	96^{a}	96^{a}
		1X		56^{b}	83^{b}	85^{b}	85^{b}	86^{b}
		2X		21^{c}	56^{c}	60^{c}	62^{c}	62^{c}

[1] Plants not harvested.

[2] Sets differing among themselves at the 5 percent probability level are followed by superscripts. Means followed by the same letter do not differ significantly.

[3] No data.

wheatgrass was also significantly reduced by the 2X treatment on sand (Table 2).

Unfortunately bur buttercup seeds failed to germinate in these greenhouse trials. The seeds apparently require some cold treatment for germination, since seed from the same lot did germinate in the cold frame experiment reported in Table 3.

Buttercup appeared to significantly inhibit growth of seedlings of fairway and western wheatgrass in the cold frame (Table 3). The results offer no evidence as to whether inhibition is caused by simple competition, allelochemic effects, or both.

The cereal grains (common rye and the fall wheats) were far more effective than perennial grass seedlings in suppressing buttercup growth in the cold frame (Table 4). The cereals germinated within two weeks of planting and attained heights of 15 cm or more prior to the onset of severe cold. Thus buttercup seedlings growing with them were heavily shaded throughout the experimental period. Buttercup plants growing with these species never produced seed.

Buttercup production was highest in rows seeded to fairway and western wheatgrasses and Russian wildrye. Fairway and crested wheatgrass differed markedly in respect to the amount of competition they offered buttercup. Although fairway yielded far more growth than crested wheatgrass, buttercup yields were over twice as great in rows sown to fairway as opposed to crested wheatgrass.

Discussion and Conclusions

Klikoff (1964) has postulated that the effect of tissue of one species on germination and growth of others could possibly be reduced or eliminated in soil by adsorption of reactive materials on colloidal surfaces, by microbial degradation of the material, by leaching, and/or dilution of concentration by diffusion. In this study, the leaching ef-

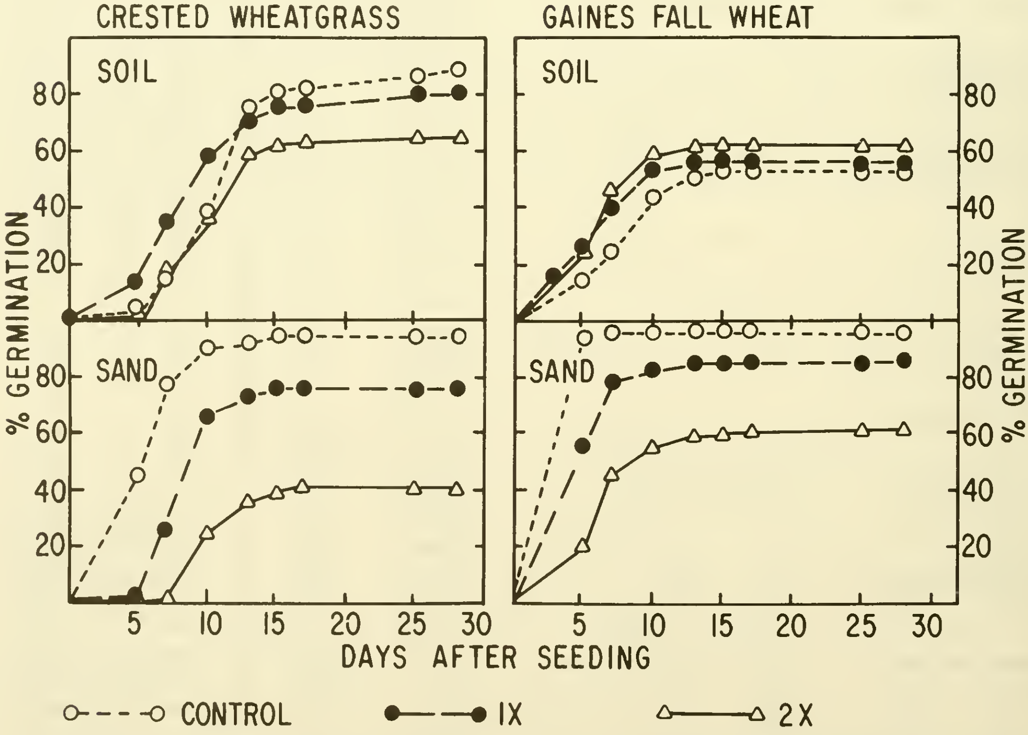


Fig. 1. Effect of three levels of bur buttercup tissue on germination of crested wheatgrass and Gaines fall wheat on Benmore soil and sand. See text for details.

Table 3. Average dry weight of grasses (g/dm of row) for three densities of associated bur buttercup plants.

Species	None (Control)	Seeding Density of Buttercup 50 Seeds per 1.5 m Row	100 Seeds per 1.5 m Row	F-Value
Crested wheatgrass	1.94	2.02	2.40	.30
Fairway wheatgrass	7.52	3.36	4.26	3.99*
Intermediate wheatgrass	8.24	6.99	7.60	.31
Pubescent wheatgrass	9.21	9.74	8.76	.14
Western wheatgrass	1.47	.50	.14	14.16*
Russian wildrye	1.63	1.06	1.31	.54
Common rye	11.07	6.81	10.68	9.53*
Delmar fall wheat	6.68	4.74	8.13	2.25
Gaines fall wheat	9.67	4.76	10.70	4.80*

*Significant at the 5 percent probability level (analysis of variance).

fect was minimized by the use of undrained pots, but the diffusion of material into the greater volume of pots as opposed to petri dishes could partially account for the reduced effect of buttercup tissue on germination and growth of test species in sand or soil. Differential effect of the tissue in sand and soil also implies that adsorption and/or microbial decomposition are operative. Greater adsorption would be expected in silty clay soil than in sand which would have considerably less surface area. Furthermore, decomposition may well be more rapid in this soil, since sands tend to support smaller microbial populations than do heavier textured soils (Clark 1957).

In view of the effect of soil texture on action of an allelopathic agent as observed in this study, it is of interest that del Moral and Cates(1971:1033) conclude that the capacity of soil to detoxify allelopathic compounds is unpredictable. Their results are perhaps related to the fact that they used a moistened sponge rather than uncontaminated soil as a control. A comparison of the germination response of our species on filter paper and in soil (Tables 1 and 2) demonstrates that germination of several species was reduced in soil (as opposed to filter paper) even without the addition of allelopathic material. There is thus a clear need to perform additional experiments before soil texture is dismissed as a significant variable affecting the action of allelopathic compounds.

The pot trials (Table 2) demonstrate that buttercup tissue in quantities that might be expected under field conditions is capable of reducing germination and retarding growth of at least some species under natural conditions. These tendencies may well be accumulative under conditions in which comparable amounts of tissue are added to the system each growing season. The cold frame studies also demonstrate that buttercup seedlings severely suppress the growth of some grasses.

Fairway and western wheatgrass, two species having growth significantly inhibited when competing with buttercup in the cold frame trials, were both slow germinators. Rapid germination of buttercup may give this species a competitive advantage for water, nutrients, and space. Thus, the suppression of these species by buttercup may be related to slow development and growth habit rather than to allelopathic action.

The differing performance of buttercup

Table 4. Total top growth (grams dry wt) of bur buttercup seeded at two rates with various grasses.

Competing Species	Seeding Density of Buttercup 50 Seeds/ 1.5 m Row	100 Seeds/ 1.5 m Row
None	50	80
Crested wheatgrass	17	26
Fairway wheatgrass	43	77
Intermediate wheatgrass	27	34
Pubescent wheatgrass	25	40
Western wheatgrass	60	52
Russian wildrye	31	73
Common rye	0.2	0.3
Delmar fall wheat	0.1	0.1
Gaines fall wheat	0.1	0.01

when grown with fairway and crested wheatgrass, two very closely related species, is remarkable. Although crested wheatgrass produced only about one-half as much biomass as fairway (Table 3), buttercup production was threefold greater when grown with the latter species. Such disparity in performance of buttercup merits further study.

Although bur buttercup has been shown to display allelopathic effects against several grasses, the effects may be of limited importance under most field conditions. Any chemical effects which the species might exert are expected to be most pronounced against slow-developing species growing on coarse-textured soils. Since maximum abundance of bur buttercup occurs on fine-textured soil (Buchanan 1969), adsorption and decomposition of toxic compounds would be expected to be rapid. Certainly no obvious suppression of associated species is seen in the field. Rapid development in late winter and early spring probably contributes more to competitive ability of buttercup than does allelopathy.

Literature Cited

Benson, L. 1948. A treatise on the North American Ranunculi. Am. Midl. Nat. 40:1-261.

Buchanan, B. A. 1969. The life history and ecology of bur buttercup, *Ranunculus testiculatus* Crantz. Master's thesis, University of Utah, Salt Lake City. 102 p.

Clark, F. E. 1957. Living organisms in the soil, p. 157-165. *In*: Soil. The 1957 Yearbook of Agriculture, U.S. Department of Agriculture. U.S. Government Printing Office, Washington. 784 p.

Clark, I. 1941. Unpublished memorandum. Files of Intmtn. Forest and Range Exp. Sta., Ogden, Utah.

Cochran, W. G. and G. M. Cox. 1957. Experimental designs, 2d ed. John Wiley and Sons, Inc., New York. 611 p.

Davis, P. H. 1965. Flora of Turkey and the East Aegean Islands, Vol. 1. Edinburgh University Press, Robert Cunningham and Sons Ltd., Great Britain. 567 p.

del Moral, R., and R. G. Cates. 1971. Allelopathic potential of the dominant vegetation of western Washington. Ecology 52:1030-1037.

Holmgren, A. H., and J. L. Reveal. 1966. Checklist of the vascular plants of the Intermountain Region. U.S. Forest Service Research Paper INT-32. Intmtn. Forest and Range Exp. Sta., Forest Service, U.S. Dept. Agr., Ogden, Utah. 160 p.

Klikoff, L. G. 1964. The toxicity of *Beta vulgaris* fruits as an inhibitor of germination of grass fruits and as an autotoxin. Northw. Sci. 38(2):43-51.

Stewart, G. 1941. Unpublished memorandum. Files of Intmtn. Forest and Range Exp. Sta., Ogden, Utah.

NEW SPECIES OF NEARCTIC *NEOPERLA* (PLECOPTERA: PERLIDAE), WITH NOTES ON THE GENUS

Bill P. Stark[1] and Richard W. Baumann[2]

Abstract.— The Nearctic *Neoperla* are reviewed. Eight species, placed in two nominal groups, are recognized. *Neoperla carlsoni*, new species, *N. catharae*, new species, *N. choctaw*, new species, *N. freytagi*, new species, *N. gaufini*, new species, and *N. stewarti*, new species, are described for male, female, and egg. Male holotypes and female allotypes are designated for each species. *Neoperla mainensis* Banks and *N. clymene* (Newman) are redescribed and *mainensis* is raised to species. Descriptions are supported by original drawings and stereoscan photomicrographs. Relationships of Nearctic species groups to the world fauna are discussed.

Needham and Claassen (1925) established the concept of *Neoperla clymene* (Newman) as a widespread, variable species. Frison (1935) accepted this usage, and Hynes (1952) and Ricker (1952) reiterated variability of the species.

Recent studies of Ethiopian *Neoperla* (Zwick 1973a,b) suggest the need for critical examination of Nearctic populations of the genus. Preliminary results, from material at hand, indicate a minimum of eight species in the complex. Descriptions of these are presented herein.

Neoperla carlsoni, n. sp.

Figs. 1, 2, 3, 4, 5, 65, 66

Neoperla sp. A: Stewart, Stark & Huggins, 1976:378.

Male.— Macropterous. Length of forewings 5–7 mm; length of body 5–7 mm. Dorsum of head yellow with brown markings on anterior region of frons. Pronotum brown with darker rugosities and sutures, a narrow pale stripe extending along median suture. Tibiae, tarsi, and apical half of femora dark brown. Wings amber, veins brown; coastal margin pale yellow. Process of tergum 7 slender, ventrally spinulose, extending to near posterior margin of tergum 8. Process of tergum 8 abruptly elevated on posterior margin, slightly spinulose. Spinules absent from membrane of tergum 8. Mesal spinule patch of tergum 9 with 6–10 spinules, lateral patches absent. Shaft of aedeagus with external spines arranged in two ventral groups; left grouping with 25–35 spines, right grouping with 5–8 spines. Extrusible, apical section of aedeagus heavily spiculate and armed basally with scattered spines.

Female.— Macropterous. Length of forewings 8–10 mm; length of body 8–10 mm. Color pattern similar to male. Subgenital plate slightly produced, posterior margin rounded and slightly notched. Vagina without sclerites; spermatheca short and completely lined with golden-brown spinulae in basal half.

Egg.— Outline oval, cross section circular. Collar distinctly stalked. Chorion uniformly, finely punctate.

Types.— Holotype (♂) and allotype (♀) from Rocky Comfort Creek, 7 mi S Quincy, Gadsden Co., Florida, 16-IV-1967, W. L. & J. G. Peters. Holotype, # 73355, and allotype deposited at the U.S. National Museum. Paratypes: FLORIDA: *Gadsden Co.*, Rocky Comfort Creek, 10-VI-1970, W. L. Peters, et al., 3 ♂ 1 ♀ (BPS); same data, 10-VIII-1967, G. Cooper, et al., 1 ♂ (FAM). *Okaloosa Co.*, Blackwater River, 8-V-1972, W. L. Peters, et al., 1 ♀ (FAM). *Santa Rosa Co.*, Blackwater River, Riley Landing, 7-VIII-1971, W. L. Peters, et al., 2 ♂ (FAM). *Walton Co.*, Alaqua Creek, 21-VI-1971, P. H. Carlson, et al., 3 ♂ (PHC). LOUISIANA: *Grant Par.*, Pollock, 24-VII-1967, E. A. Cancienne, 1 ♂ (NTSU). *Livingston Par.*, Little Natalbany River, Albany, 27-VI-1973, B. Stark, 1 ♂ 3 ♀ (BPS).

---

[1] Department of Biology, Mississippi College, Clinton, Mississippi 39058.

[2] Department of Zoology, Brigham Young University, Provo, Utah 84602.

Vernon Par., Fort Polk, 18-VI-1968, L. D. Newson, 2 ♂ (NTSU). OKLAHOMA: *McCurtain Co.*, Battiest, 14-VI-1972, D. C. Arnold, 3 ♀ (NTSU). SOUTH CAROLINA: *Aiken Co.*, Three Runs Creek, 21-VII-1971, J. W. Richardson, 2 ♀ (BPS). TEXAS: *Anderson Co.*, Salmon, 7-27-VI-1975, H. R. Burke, 8 ♂ 4 ♀ (TAM) (NTSU). *Nacogdoches Co.*, Nacogdoches, 10-VI-1969, R. Dorman, 1 ♂ 1 ♀ (NTSU).

Etymology.— This species is named in honor of Mr. Paul Carlson who has made available for our study a large number of Plecoptera specimens from the southeastern United States.

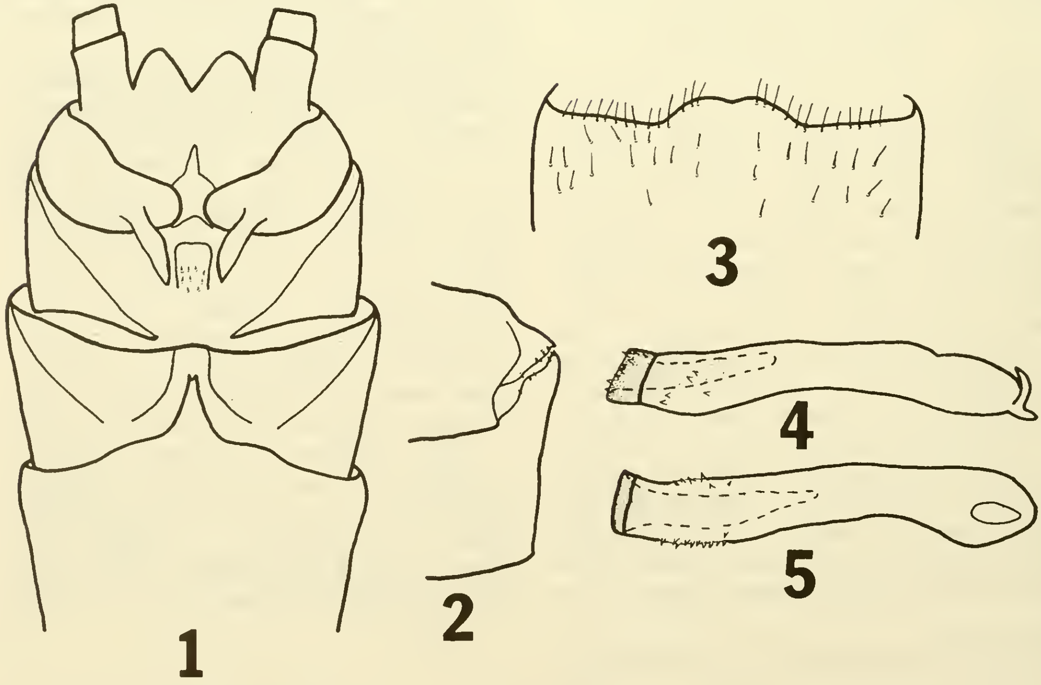
Neoperla catharae, n. sp.

Figs. 6, 7, 8, 9, 64

Male.— Macropterous. Length of forewings 5–7 mm; length of body 5–7 mm. Dorsum of head yellow with brown markings on anterior region of frons. Pronotum brown with darker rugosities and sutures. Tibiae, tarsi and apical half of femora dark brown. Wings amber, veins brown; coastal margin pale yellow. Process of tergum 7 slender, ventrally spinulose, extending to near posterior margin of tergum 8. Process of tergum 8 abruptly elevated on posterior margin, slightly spinulose. Spinules absent from membrane of tergum 8. Mesal spinule patch of tergum 9 with 6–10 spinules, lateral patches with a few scattered spinules. Shaft of aedeagus with external spines arranged in two ventral groups; left grouping with 5–12 spines, right grouping with 12–20 spines. Extrusible, apical section of aedeagus heavily spiculate and armed basally with several scattered spines.

Female.— Macropterous. Length of forewings 8–10 mm; length of body 8–10 mm. Color pattern similar to male. Subgenital plate slightly produced, posterior margin smoothly rounded to slightly notched. Vagina without sclerites; spermatheca short and completely lined with golden-brown spinulae in basal half.

Egg.— Outline oval, cross section circular. Collar distinctly stalked. Chorion smooth.



Figs. 1–5. *Neoperla carlsoni*: 1, Male terminalia, dorsal; 2, Male terga, 7 and 8, lateral; 3, Female sternum 8; 4, Aedeagus, lateral; 5, Aedeagus, ventral.

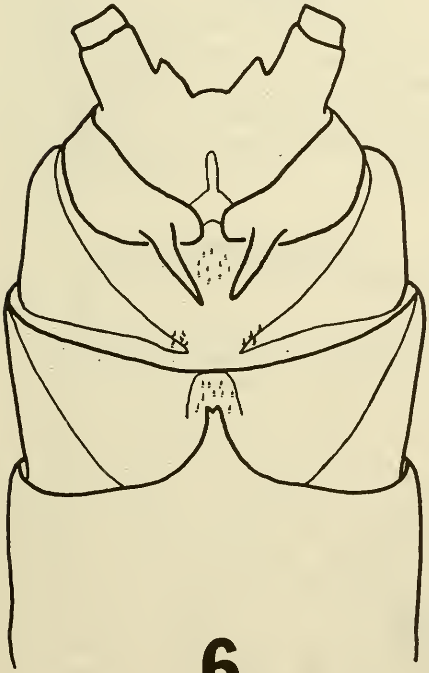
TYPES.— Holotype (♂), allotype (♀), and 11 ♀ paratypes from James Creek, Randolph Co., Arkansas, IX-1969, M. Case. Holotype, #73357, and allotype deposited at the U.S. National Museum. Paratypes: ARKANSAS: *Washington Co.*, Cove Creek, 4-VIII-1962, 4 ♀ (INHS). OHIO: *Butler Co.*, Oxford, 30-VI-1902, 1 ♂ (UU). *Warren Co.*, Todds Fork, Morrow, 15-VIII-1951, A. R. Gaufin, 2 ♂ 3 ♀ (UU) (BPS); same data, 5-VIII-1953, 7 ♀ (UU) (BPS).

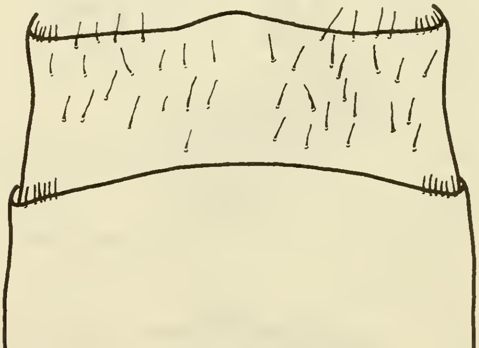
ETYMOLOGY.— This species is named for Dr. Mary Case Cather who collected the type series.

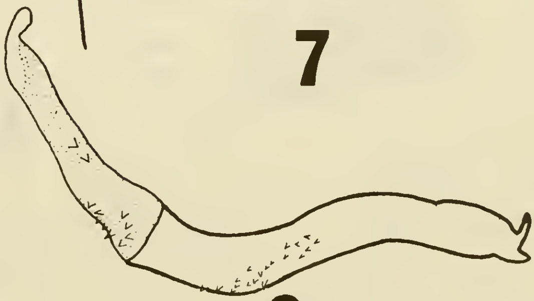
Neoperla choctaw, n. sp.

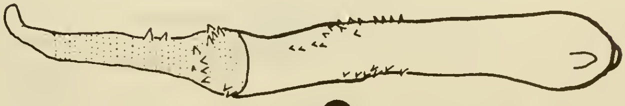
Figs. 10, 11, 12, 13, 14, 15, 16, 17, 67, 68

MALE.— Macropterous. Length of forewings 5–7 mm; length of body 5–7 mm. Dorsum of head yellow, frons without brown markings. Pronotum brown with darker rugosities and sutures. Tibiae, tarsi, and femora dark brown with distal yellow bands on tibiae and proximal yellow bands on femora. Wings and veins brown; coastal margin pale yellow. Process of tergum 7 slender, ventrally spinulose, extending to near posterior margin of tergum 8. Process of tergum 8 abruptly elevated on posterior margin, slightly spinulose. Spinules absent from membrane of tergum 8. Mesal spinule patch of tergum 9 with 5–12 spinules, lateral patches with 0–3 spinules. Shaft of aedeagus with external spines arranged in two ventral groups; left grouping with 5–10 spines, right grouping with 3–7 spines. Extrusible, apical section of aedeagus heavily spiculate and armed with several scattered spines.

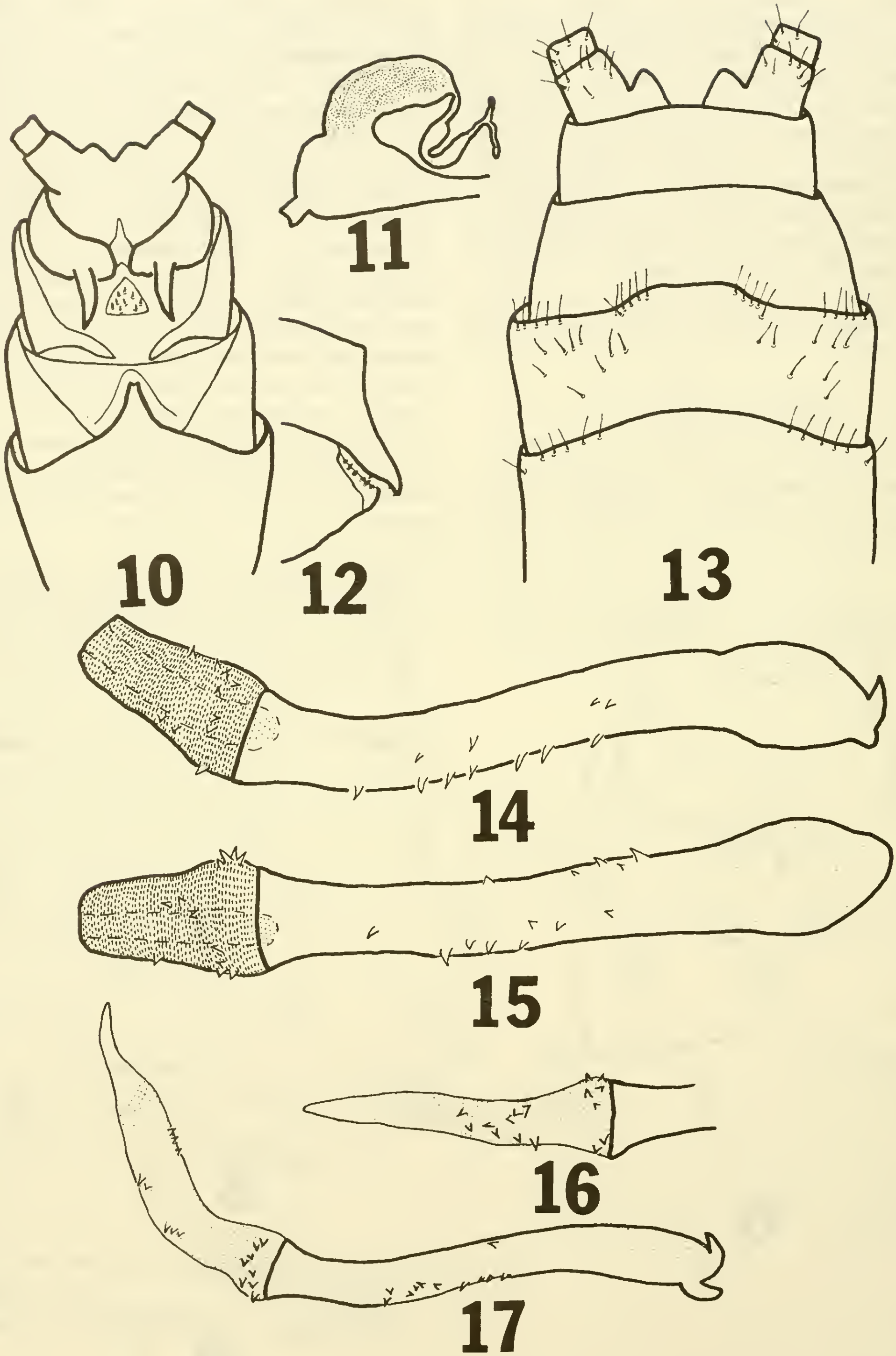

6


7


8


9

Figs. 6–9. *Neoperla catharae*: 6, Male terminalia, dorsal; 7, Female sterna 7 and 8; 8, Aedeagus, lateral; 9, Aedeagus, ventral.



Figs. 10–17. *Neoperla choctaw*: 10, Male terminalia, dorsal; 11, Vagina, lateral; 12, Male terga 7 and 8, lateral; 13, Female terminalia, ventral; 14, Aedeagus, lateral; 15, Aedeagus, ventral; 16, Apical section of aedeagus, ventral; 17, Aedeagus, apical section extruded, lateral.

Female.— Macropterous. Length of forewings 8–10 mm; length of body 8–10 mm. Color pattern similar to male. Subgenital plate slightly produced, posterior margin smoothly rounded to emarginate. Vagina without sclerites; spermatheca short and incompletely lined with golden-brown spinulae in basal half.

Egg.— Outline oval, cross section circular. Collar absent. Chorion finely punctate, with larger punctations mesally and finer punctations near polar ends.

Types.— Holotype (♂), allotype (♀), and 1 ♂ 3 ♀ paratypes from Red Oak Creek, Denman, Latimer Co., Oklahoma, 1-VII-1970, B. Stark. Holotype, # 73358, and allotype deposited at the U.S. National Museum. Paratypes: OKLAHOMA: *Latimer Co.*, Red Oak Creek, Denman, 1-2-VII-1975, B. Stark, 5 ♂ 12 ♀ (BPS) (NTSU); Turkey Creek, 6 mi E Red Oak, 2-VII-1975, B. Stark, 30 ♂ 47 ♀ (BPS) (NTSU) (INHS). WEST VIRGINIA: *Berkeley Co.*, Back Creek, 30-VII-1946, E. P. Merkel, 3 ♂ 1 ♀ (RWB) (USNM).

Etymology.— This species was discovered in the former Choctaw portion of the Indian Territory and is named in honor of that tribe.

Neoperla freytagi, n. sp.

Figs. 18, 19, 20, 21, 22, 23, 58, 59

Male.— Macropterous. Length of forewings 8–11 mm; length of body 7–10 mm. General color lemon yellow with dark brown markings. Dorsum of head with ocelli covered by a dark brown quadrangular area. Pronotum light brown with irregular darker rugosities; marginal and median sutures dark brown. Wings subhyaline, coastal margin yellow. Process of tergum 7 triangular, ventrally spinulose. Process of tergum 8 moundlike, smoothly rounded in profile and spinulose; membrane of tergum 8 with 0–2 spinules. Tergum 9 with a mesal and two lateral spinule patches; anterior margins of each spinule patch with a number of long setae. Shaft of aedeagus with a dense patch of spinules ventrally; external spines absent. Extrusible, apical section of aedeagus membranous, bearing a few small spines.

Female.— Macropterous. Length of forewings 12–14 mm; length of body 12–14 mm. Color pattern similar to male. Subgenital plate slightly produced, posterior margin straight. Vagina with a pair of sclerites; spermatheca long, incompletely lined with golden-brown spinulae from near basal third to near apex.

Egg.— Outline oval, cross section circular. Collar with two rows of irregular reticulation. Chorion longitudinally striate with alternating nonpunctate, elevated bands and depressed finely punctate bands. Micropyles irregularly placed in depressed bands. Polar third of egg with irregular 4-, 5-, or 6-sided reticulation.

Types.— Holotype (♂), allotype (♀), and 7 ♂ 24 ♀ paratypes from Larue Co., Kentucky, 16-VI-1971, P. H. Freytag & G. Leppert. Holotype, # 73356, and allotype deposited at the U.S. National Museum. Paratypes: ARKANSAS: *Benton Co.*, 24-VI-1963, O. & M. Hite, 65 ♀ (INHS). NEW YORK: *Greene Co.*, East Durham, 26-VII-1971, S. E. Thewke, 2 ♂ 6 ♀ (MU) (BPS). *Tompkins Co.*, Ithaca, 21-30-VII-1929, 2 ♂ (BPS) (DC). OHIO: *Warren Co.*, Little Miami River, Loveland, 2-VII-1953, A. R. Gaufin, 1 ♀ (RWB). ONTARIO: *Peel Co.*, Streetsville, 29-VIII-1952, G. B. Wiggins, 2 ♀ (ROM); Churchville, Credit River, 14-VII-1952, G. B. Wiggins, 2 ♀ (ROM); Erindale, Credit River, 16-VI-1952, G. B. Wiggins, 7 ♂ 2 ♀ (ROM). *Halton Co.*, Norval, Credit River, 14-VII-1952, G. B. Wiggins, 2 ♂ (ROM). SOUTH CAROLINA: *Oconee Co.*, Brasstown, 29-VI-1969, H. Douglass, 1 ♀ (BPS). *Pickens Co.*, Wildcat Creek, 25-VI/22-VII-1968, P. Carlson, 31 ♂ 18 ♀ (PHC) (BPS) (NTSU). TENNESSEE: *Sevier Co.*, Gatlinburg, 13-19-VI-1942, N. Dybas, 1 ♂ 4 ♀ (FMNH).

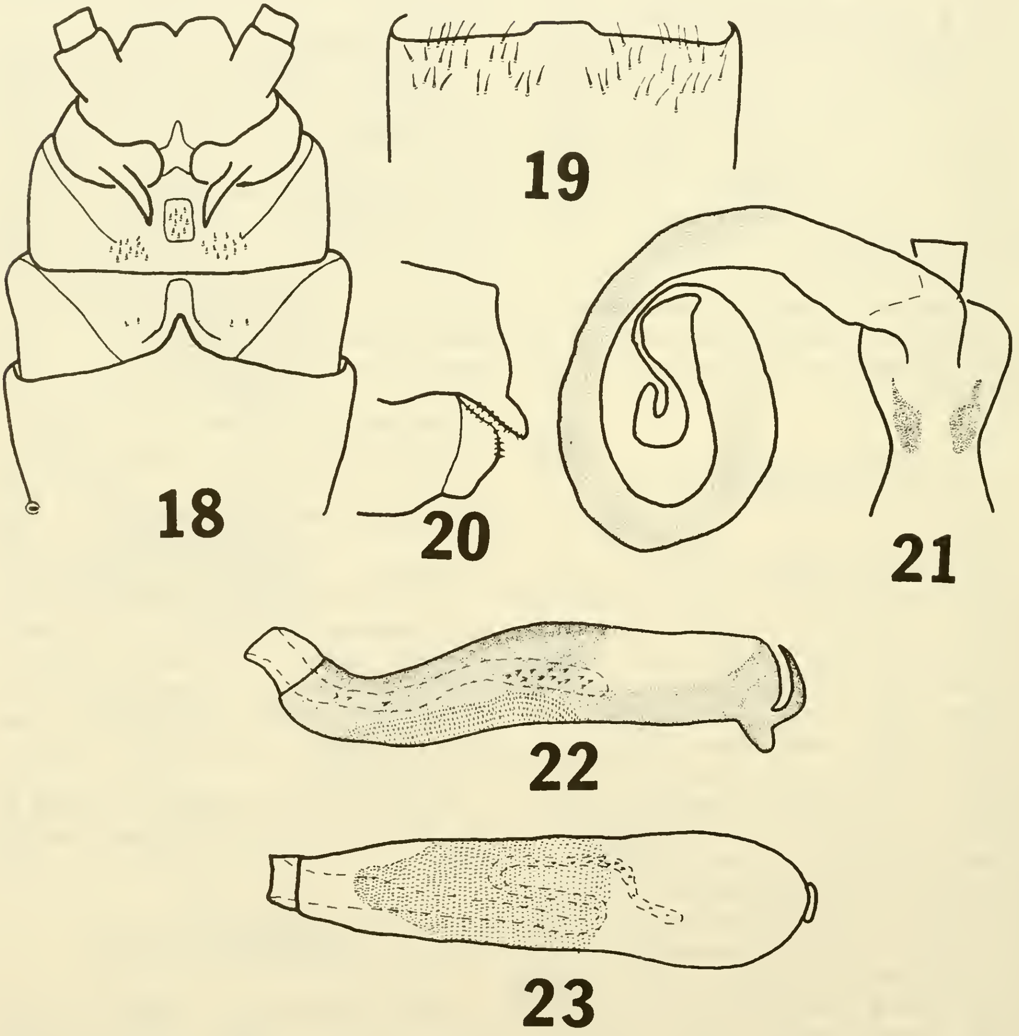
Etymology.— This species is named for Dr. Paul Freytag who collected the type series.

Neoperla gaufini, n. sp.

Figs. 24, 25, 26, 27, 28, 69, 70

Male.— Macropterous. Length of forewings 6–8 mm; length of body 6–8 mm. Dorsum of head yellow with brown markings on occiput, between ocelli and on lateral margins of frons. Pronotum brown with darker rugosities and sutures. Tibiae, tarsi, and femora dark brown with distal yellow bands on tibiae and proximal yellow bands on femora. Wings and veins brown, coastal margin pale yellow. Process of tergum 7 slender, ventrally spinulose, extending to apical third of tergum 8. Process of tergum 8 abruptly elevated on posterior margin, slightly spinulose. Spinules absent from membrane of tergum 8. Mesal spinule patch of tergum 9 with 5–12 spinules, lateral patches with 3–6 scattered spinules. Shaft of aedeagus with external spines arranged in two ventral groups; left grouping with 2–6 spines, right gruping with 6–10 spines. Extrusible, apical section heavily spiculate and armed with several scattered spines.

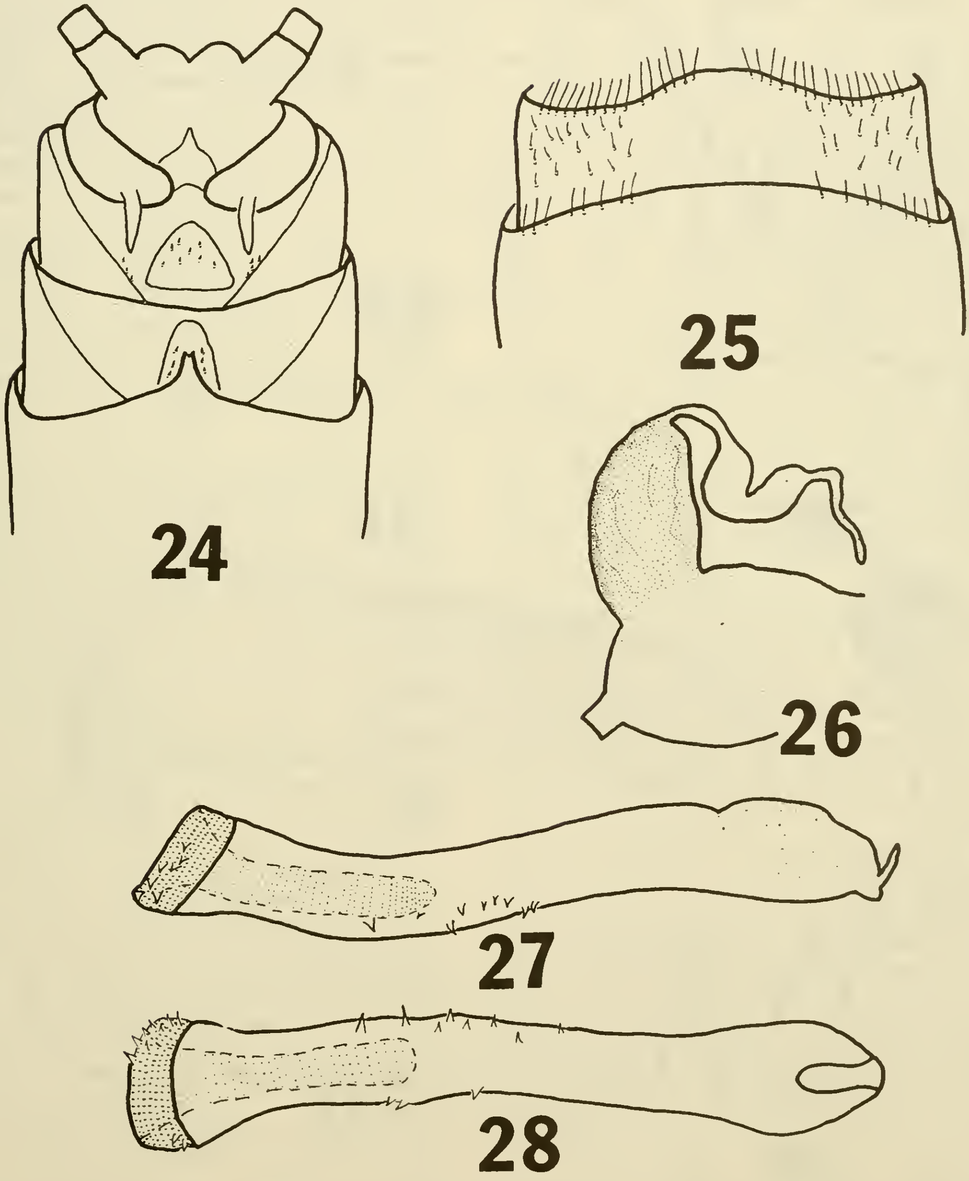
Female.— Macropterous. Length of forewings 7–9 mm; length of body 7–9 mm. Color pattern similar to male. Subgenital plate slightly produced, posterior margin smoothly rounded to emarginate. Vagina without sclerites; spermatheca short and completely lined with golden-brown spinulae in basal half.



Figs. 18–23. *Neoperla freytagi*: 18, Male terminalia, dorsal; 19, Female sternum 8; 20, Male terga 7 and 8, lateral; 21, Vagina, dorsal; 22, Aedeagus, lateral; 23, Aedeagus, ventral.

Egg.— Outline oval, cross section circular. Collar absent. Chorion covered with large regular depressions.

Types.— Holotype (♂), allotype (♀), and 1 ♂ 6 ♀ paratypes from Little Miami River, Morrow, Warren Co., Ohio, 26-VI-1952, A. R. Gaufin. Holotype, # 73354, and allotype deposited at the U.S. National Museum. Paratypes: INDIANA: *Jefferson Co.*, Clifty Falls State Park, 18-VII-1972, A. Provonsha & E. Levine, 1 ♀ (PU). KENTUCKY: *Shelby Co.*, Brashears Creek, 3-VIII-1972, D. White, 1 ♀ (BPS). *Spencer Co.*, Salt River, 25-26-VI-1971, V. Resh & D. White, 1 ♂ 1 ♀ (BPS). OHIO: *Clinton Co.*, Cowan Creek, 5-VI-1951, A. R. Gaufin,



Figs. 24–28. *Neoperla gaufini*: 24, Male terminalia, dorsal; 25, Female sterna 7 and 8; 26, Vagina, lateral; 27, Aedeagus, lateral; 28, Aedeagus, ventral.

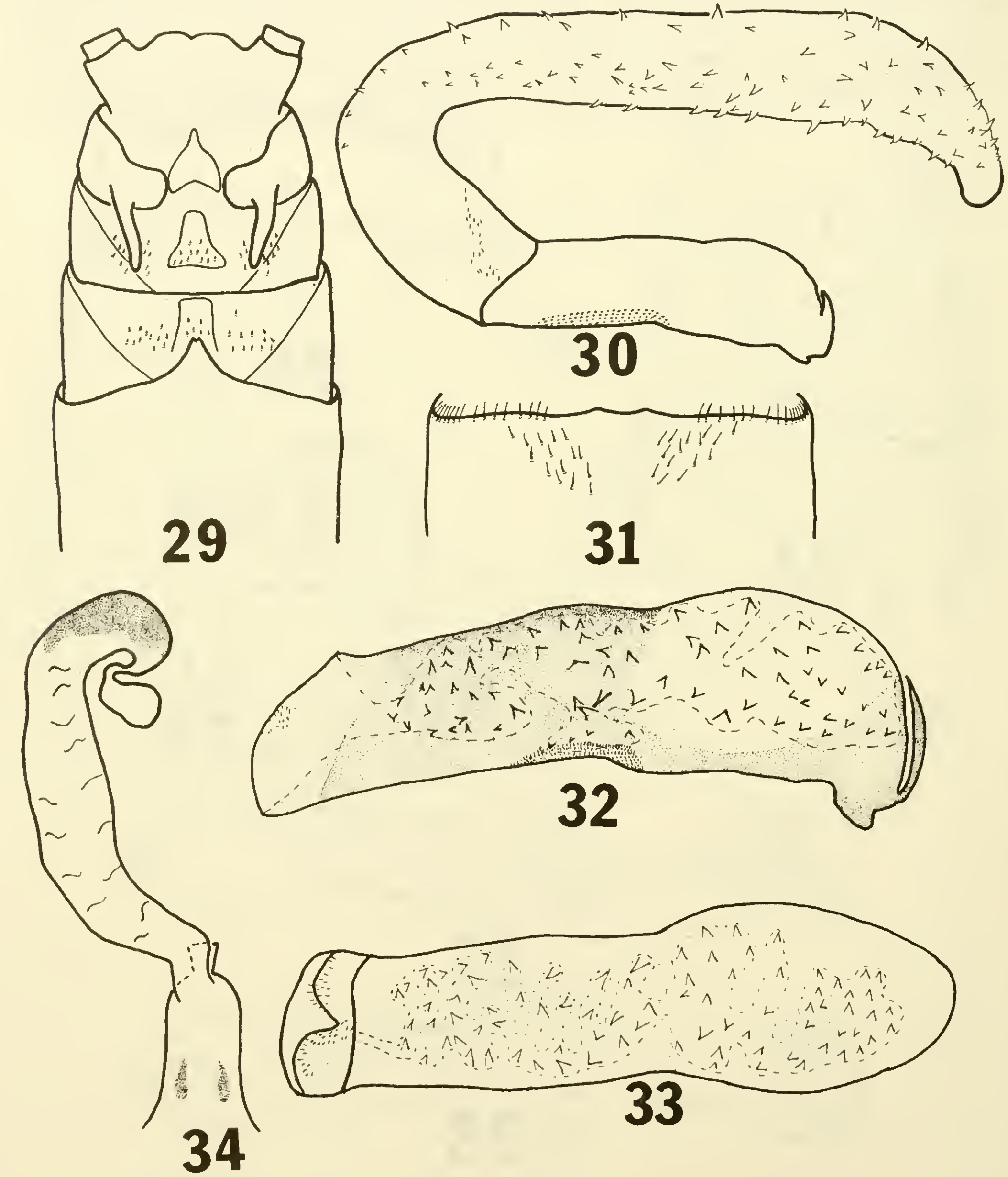
9 ♂ 17 ♀ (UU) (BPS) (NTSU). *Warren Co.*, Little Miami River, Loveland, 2-VII-1953, A. R. Gaufin, 5 ♂ 10 ♀ (RWB) (USNM).

Etymology.— This species is named in honor of Dr. A. R. Gaufin who collected it and labeled it "*Neoperla* n. sp." in the early 1950s.

Neoperla stewarti, n. sp.

Figs. 29, 30, 31, 32, 33, 34, 63

Male.— Macropterous. Length of forewings 9–11 mm; length of body 9–11 mm. Dorsum of head yellow with diffuse brown markings on anterior region of frons; ocellar area dark brown. Pronotum brown with



Figs. 29–34. *Neoperla stewarti*: 29, Male terminalia, dorsal; 30, Aedeagus, apical section extruded, lateral; 31, Female sternum 8; 32, Aedeagus, lateral; 33, Aedeagus, ventral; 34, Vagina, dorsal.

darker rugosities and sutures. Dorsum of tibiae and femora brown becoming lighter on ventral surface and apically; tarsi dark brown. Process of tergum 7 triangular, ventrally spinulose, extending to near middle of tergum 8. Process of tergum 8 moundlike, smoothly rounded in lateral view and spinulose; membrane of tergum 8 with 5 or more spinules on each side of process. Tergum 9 with a mesal and 2 lateral spinule patches; anterior margins of each spinule patch with a number of long setae. Shaft of aedeagus with a small dense pad of spinules ventrally; external spines absent. Extrusible, apical section of aedeagus membranous, heavily armed with large spines and a basal group of small spinules.

Female.— Macropterous. Length of forewings 11–13 mm; length of body 10–12 mm. Color pattern similar to male. Subgenital plate slightly produced, or unproduced. Vagina with paired sclerites; spermatheca long and lined with golden-brown spinulae in apical third.

Egg.— Outline oval, cross section circular. Collar with a single irregular row of reticulation. Chorion longitudinally striate with alternating nonpunctate, elevated bands and depressed finely punctate bands. Some elevated bands branch near midline. Micropyles irregularly placed in depressed bands. Polar third of egg with irregular 4-, 5-, or 6-sided reticulation.

Types.— Holotype (♂), allotype (♀), and 22 ♂ 3 ♀ paratypes from Larue Co., Kentucky, 16-VI-1971, P. H. Freytag & G. Leppert. Holotype, # 73353, and allotype deposited at the U.S. National Museum. Paratypes: ARKANSAS: *Washington Co.*, White River, rt. 68, 4-VI-1963, L. O. Warren, 2 ♂ 11 ♀ (RWB) (USNM). MISSISSIPPI: *Lauderdale Co.*, Meridian, 1-VI-1968, B. Stark, 1 ♂ (BPS). OHIO: *Hocking Co.*, 18-VI-1938, E. S. Thomas, 1 ♂ (UU). *Jackson Co.*, 11-VI-1933, D. Smith, et al., 1 ♂ (UU); Washington Township, 6-VII-1935, E. S. & J. H. Thomas, 1 ♂ (UU). *Warren Co.*, Morrow, 23-26-VI-1952, A. R. Gaufin, 10 ♂ 21 ♀ (UU) (BPS); Todd Fork, 19-VI-1952, A. R. Gaufin, 3 ♂ 34 ♀ (UU) (BPS); same data, 11-VII-1953, 1 ♂ 7 ♀ (UU). WISCONSIN: *Douglas Co.*, St. Croix River, Dairyland, 20-VII-1967, A. Lemke, 1 ♂ (BPS).

Etymology.— This species is named in honor of Dr. K. W. Stewart who introduced the senior author to Plecoptera.

Neoperla mainensis Banks, new status

Figs. 35, 36, 37, 38, 60, 61, 62

Neoperla clymene mainensis Banks, 1948: 124. Holotype ♂; Rome, Maine (MCZ # 27725).

Male.— Macropterous. Length of forewings 7–10 mm; length of body 7–10 mm. Dorsum of head diffuse brown to black, yellow around margins. Pronotum brown with darker rugosities and sutures. Tibiae, tarsi, and femora brown. Wings and veins brown, coastal margin pale yellow. Process of tergum 7 short, broadly triangular and spinulose ventrally. Process of tergum 8 moundlike, smoothly rounded in lateral view and spinulose; membrane of tergum 8 with numerous spinules on both sides of process. Tergum 9 with a mesal and 2 lateral spinule patches; anterior margins of each spinule patch with a number of long setae. Shaft of aedeagus abruptly bent near apex and with ventral and dorsal patches of spinules; external spines absent. Extrusible, apical section of aedeagus membranous, bearing many small spines.

Female.— Macropterous. Length of forewings 10–12 mm; length of body 10–12 mm. Color pattern similar to male. Subgenital plate moderately produced, triangular in outline and apically notched. Vagina with a pair of sclerites; spermatheca long, incompletely lined in apical half with golden-brown spinulae.

Egg.— Outline oval, cross section circular. Collar distinct, with two or three rows of irregular reticulation. Chorion longitudinally striate with alternating nonpunctate, elevated bands and depressed finely punctate bands; two elevated bands arising from a single reticulation point at collar join different reticulation points at polar end. Polar third of egg with irregular 4-, 5-, or 6-sided reticulation.

Specimens examined.— MAINE: *Kennebec Co.*, Rome, 26-VI/8-VII-1944, A. Loveridge, 6 ♂ 1 ♀ (Type series, MCZ). OHIO: Put-in-Bay, 22-VI-1920, 11 ♂ 3 ♀ (UU) (BPS).

Neoperla clymene (Newman)

Figs. 39, 40, 41, 42, 43, 44, 45, 56, 57

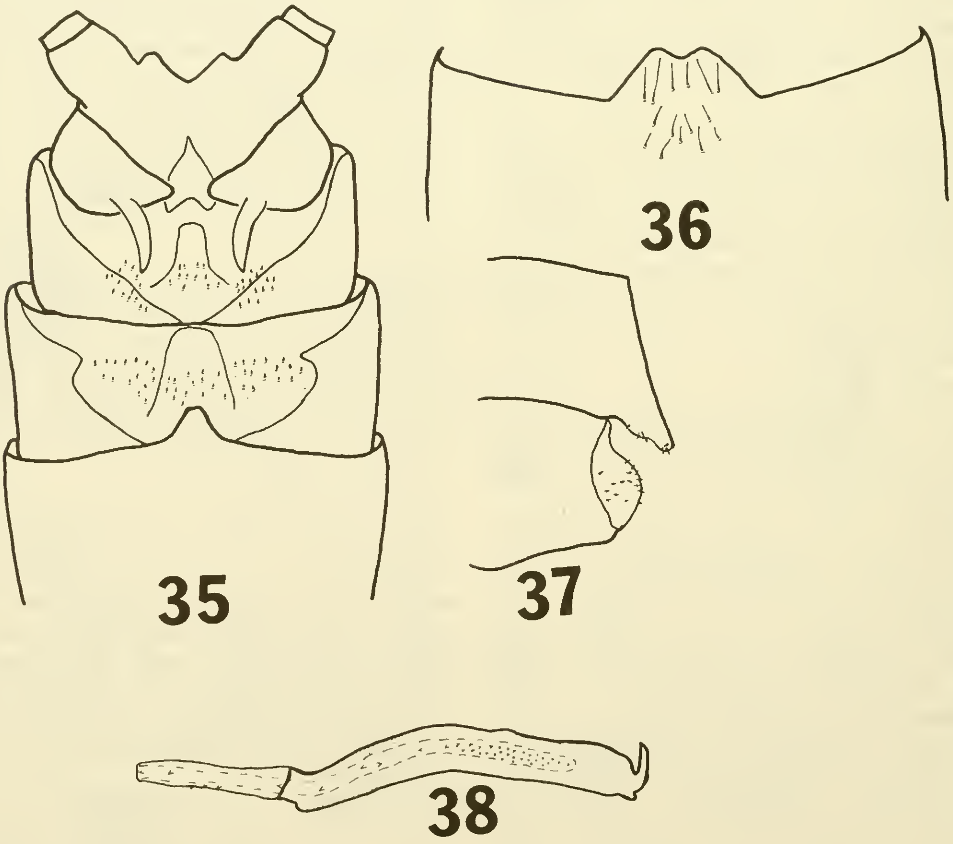
Chloroperla clymene Newman, 1839: 87. Holotype ♀; Georgia (BMNH).

Perla occipitalis Pictet, 1841: 254. Syn. Needham & Claassen, 1925.

MALE.— Macropterous. Length of forewings 9–12 mm; length of body 8–11 mm. Dorsum of head yellow with diffuse brown markings around anterior margin of frons; ocellar area with or without brown pigmentation. Pronotum brown with darker rugosities and sutures, a narrow pale stripe extending along median suture. Wings subhyaline, veins brown; coastal margin pale yellow. Tibiae, tarsi, and femora brown. Process of tergum 7 short, triangular, and ventrally spinulose. Process of tergum 8 moundlike, smoothly rounded in lateral view and spinulose; membrane of tergum 8 without spinules. Tergum 9 with a mesal and 2 lateral spinule patches; anterior margins of spinule patches with long setae. Shaft of aedeagus without spinulae or spines. Extrusible, apical section of aedeagus membranous, bearing many spines.

FEMALE.— Macropterous. Length of forewings 13–15 mm; length of body 12–15 mm. Color pattern similar to male. Subgenital plate unproduced. Vagina with a pair of sclerites; spermatheca long, incompletely lined apically with golden-brown spinules.

EGG.— Outline oval, cross section circular. Collar with two irregular rows of reticulation. Chorion longitudinally striate with alternating nonpunctate, elevated bands and depressed, finely punctate bands. Micropyles irregularly placed in depressed bands. Polar

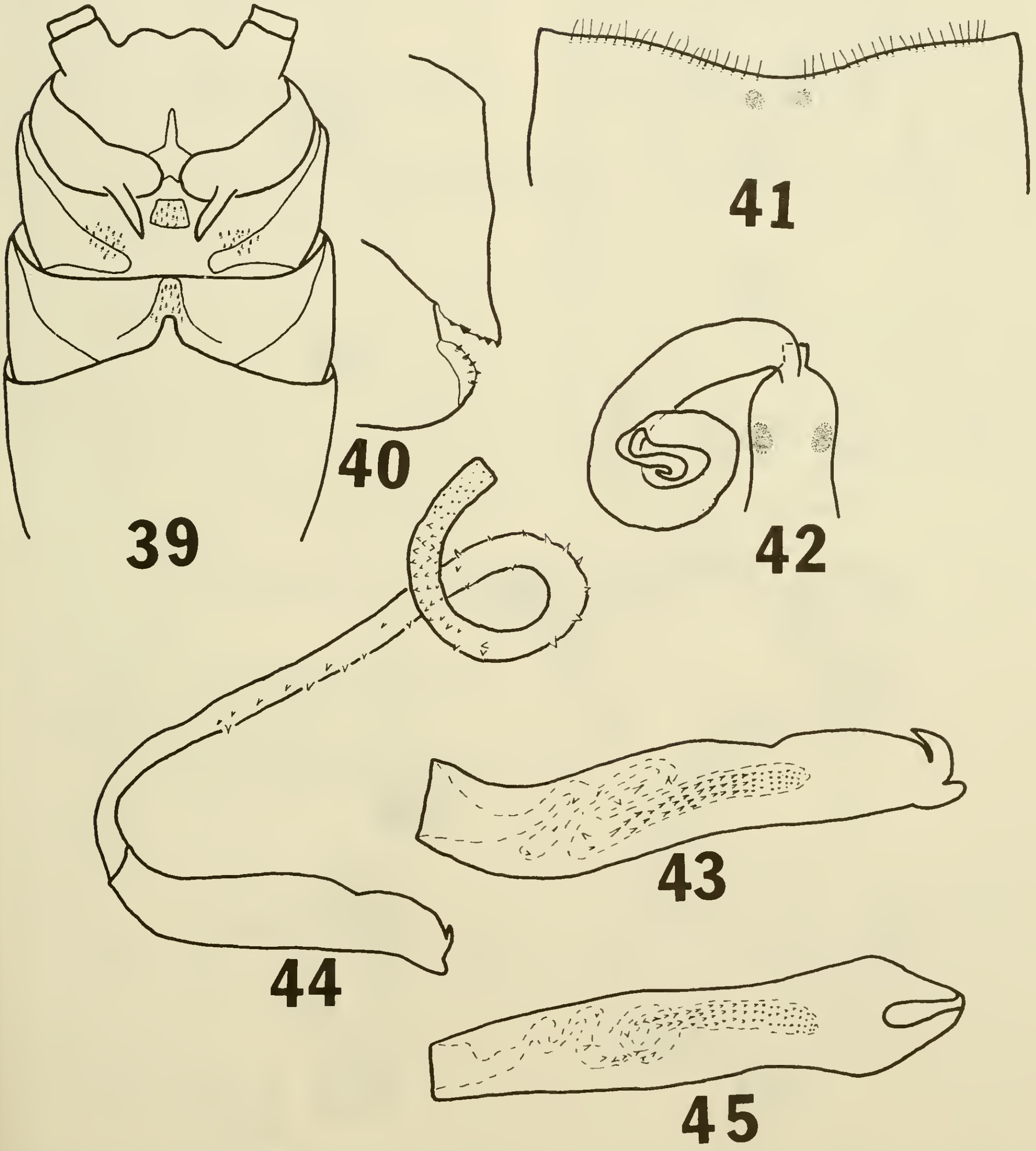


Figs. 35–38. *Neoperla mainensis*: 35, Male terminalia, dorsal; 36, Female sternum 8; 37, Male terga 7 and 8, lateral; 38, Aedeagus, lateral.

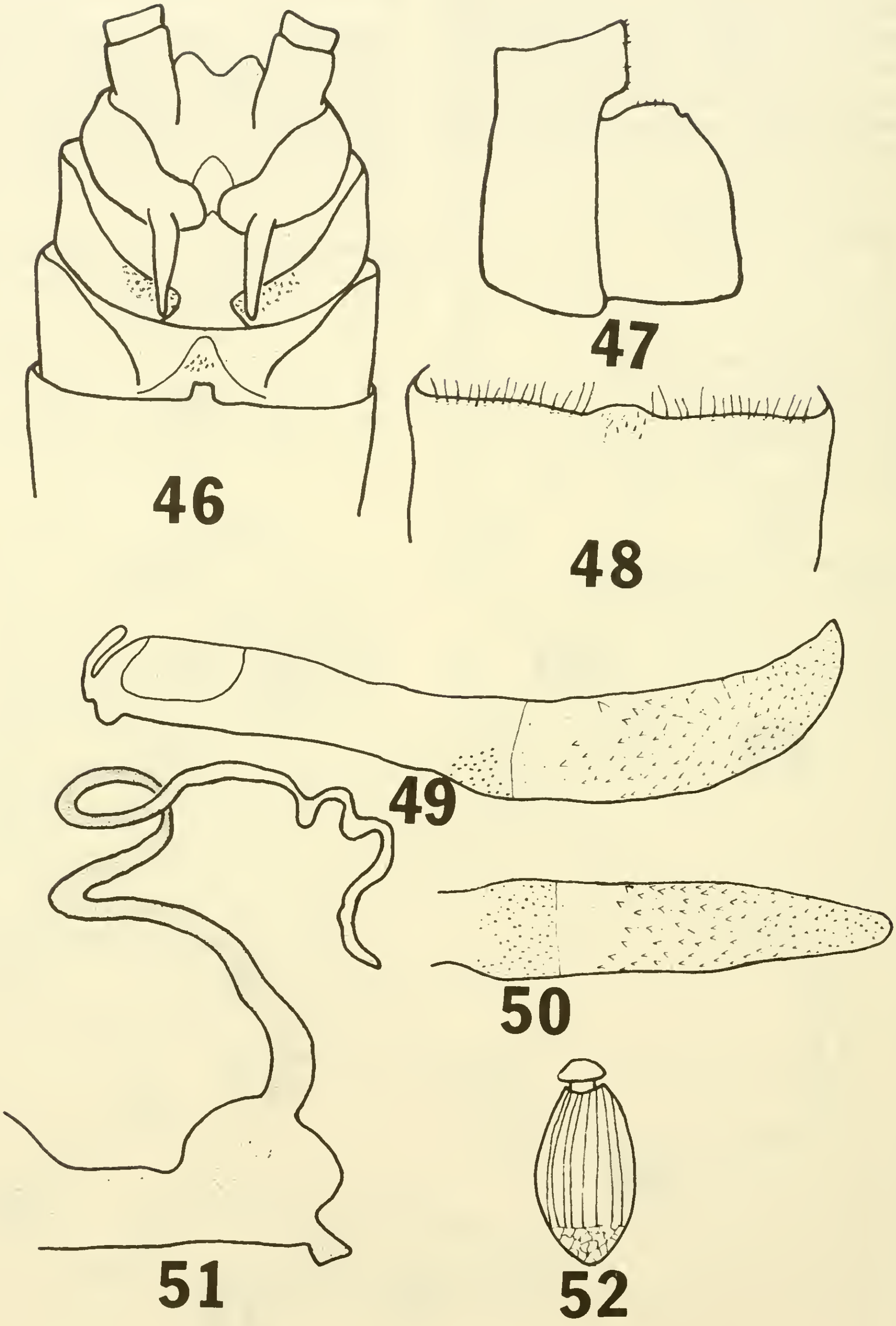
third of egg with irregular 4-, 5-, or 6-sided reticulation.

Specimens examined.— ALABAMA: Escambia Co., Tuscaloosa Co. FLORIDA: Gadsden Co., Liberty Co., Okaloosa Co., Putnam Co. GEORGIA: Appling Co., Burke Co. LOUISIANA: East Baton Rouge Par., Livingston Par., St. Tammany Par. MISSISSIPPI: Oktibbeha Co. NEW YORK: Tompkins Co. OKLAHOMA: Adair Co., Bryan Co., Cherokee Co. TEXAS: Bell Co., Dewitt Co., Nacogdoches Co., Palo Pinto Co.

Discussion.— Nearctic *Neoperla* fall readily into two species complexes. The first of these, the *choctaw* group (*choctaw*, *catharae*, *carlsoni*, *gaufini*), includes species whose males have external spines on the ae-



Figs. 39–45. *Neoperla clymene*: 39, Male terminalia, dorsal; 40, Male terga 7 and 8, lateral; 41, Female sternum 8; 42, Vagina, dorsal; 43, Aedeagus, lateral; 44, Aedeagus, apical section extruded, lateral; 45, Aedeagus, ventral.



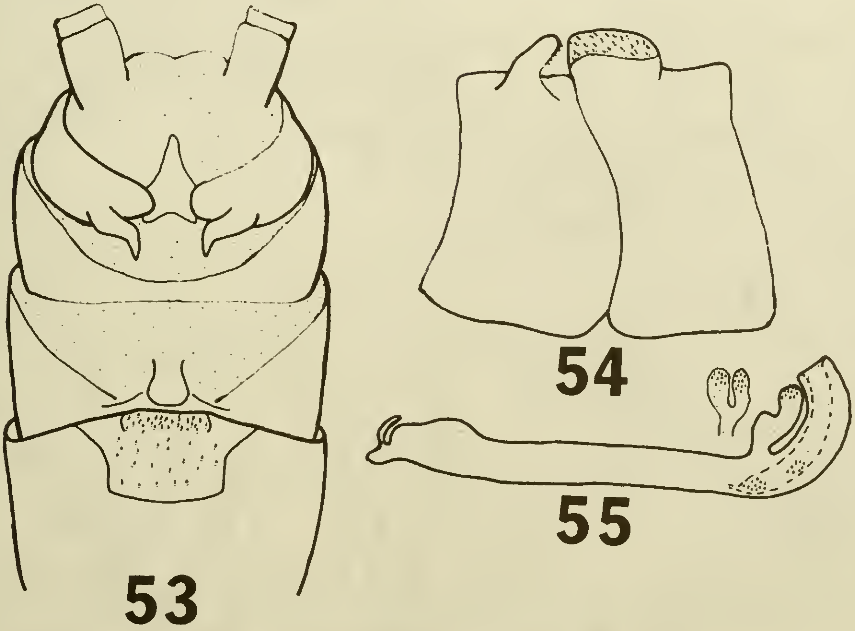
Figs. 46–52. *Neoperla* sp., Gold Coast, Africa: 46, Male, terminalia, dorsal; 47, Male, terga 7 and 8, lateral; 48, Female sternum 8; 49, Aedeagus, lateral; 50, Aedeagus, ventral; 51, Vagina, lateral; 52, Egg.

deagal shaft and a spiculate apical section of the aedeagus. Females have a short spermatheca lined basally with spinulae, lack vaginal sclerites, and have nonstriate chorionic reticulation of the ova. Previous studies of exotic *Neoperla* (Hynes 1952, Kawai 1967, Wu 1938, Zwick 1972, 1973a,b) have not included species which are conclusively of this group, although Zwick's (1973b) *Neoperla* sp. 11 from Ghana appears similar in egg and vaginal characters to *catharae*.

The *clymene* group (*clymene, freytagi, mainensis, stewarti*) includes species whose males lack external spines or spiny lobes on the aedeagal shaft but have the membranous apical section covered irregularly with spines. The process of tergum 7 is short and triangular and the process of tergum 8 is moundlike, small, and covered with spinules. Females have a long spermatheca irregularly lined with spinulae, vaginal sclerites are generally present, and the egg is striate. As Zwick (1973b) noted, this is a large, widespread group occurring in Africa, Asia, and North America. Figures 46–52 show details of an undetermined member of this group from Gold Coast, Africa.

The species *N. hubbsi* Ricker is allied to another group which includes *N. geniculata* (Pictet) and *N. nipponensis* (McLachlan). This group is distinguished primarily by modifications of the processes on terga 7 and 8, and many species have prominent spiny lobes on the aedeagal shaft. Data on female genitalia and egg morphology are unavailable. Figures 53-55 show details of an undetermined member of this group from Thailand. We are convinced on the basis of personal collecting at the supposed type locality and from correspondence with museum personnel at the University of Michigan that the holotype specimen of *hubbsi* came from the Eastern Hemisphere rather than from Kansas.

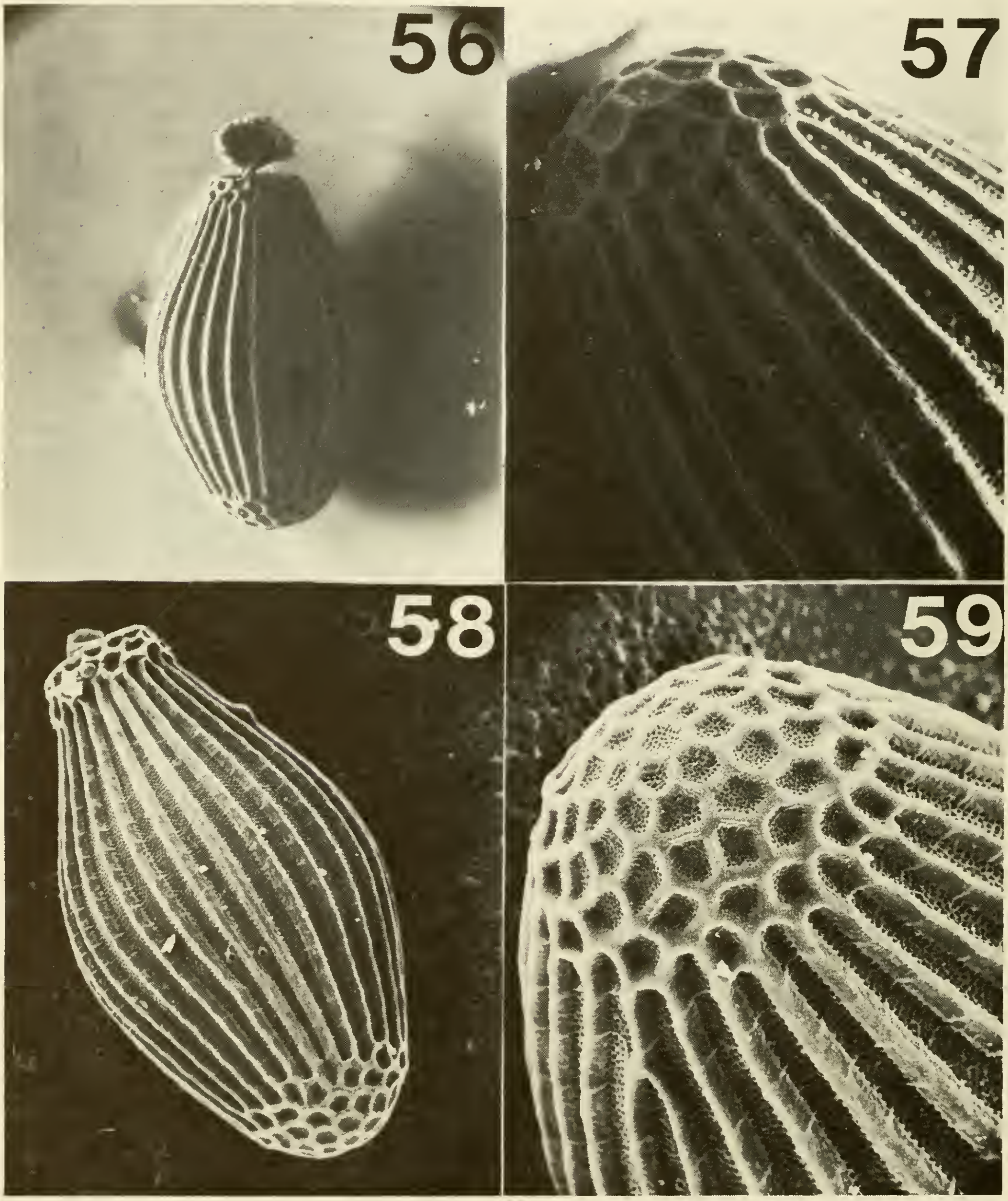
Within each group, Nearctic species are most easily diagnosed on the basis of aedeagal, vaginal, and egg characters. *Neoperla carlsoni* (25–35 spines), and *choctaw* (5–10 spines) have the greatest concentrations of external spines on the left side of



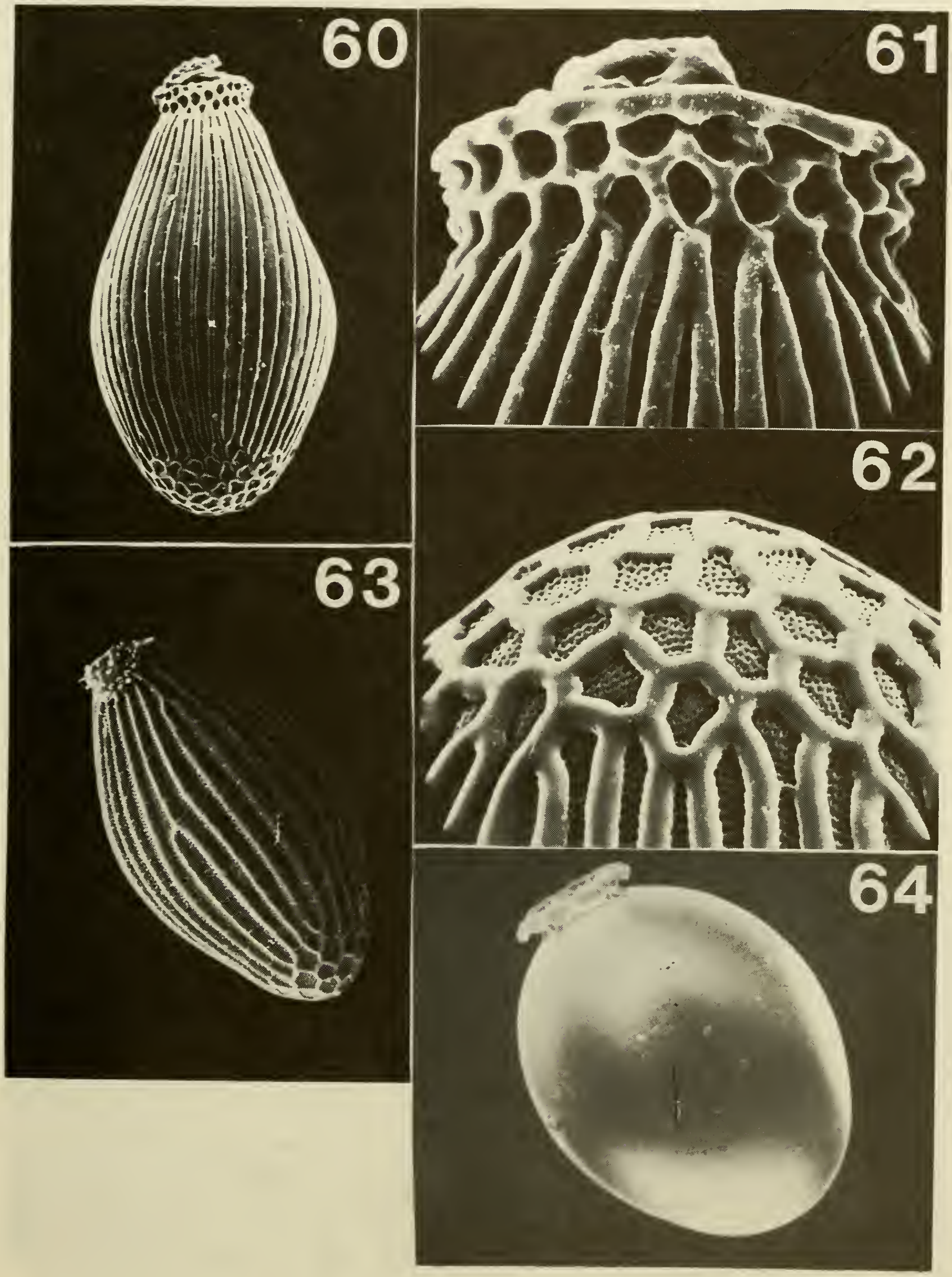
Figs. 53–55. *Neoperla* sp., Thailand: 53, Male terminalia, dorsal; 54, Male, terga 7 and 8, lateral; 55, Aedeagus, lateral.

the aedeagal shaft (ventral view), and *catharae* (12–20 spines) and *gaufini* (6–10 spines) have the greatest number of spines on the right side of the aedeagal shaft. Females are easily distinguished by details of chorionic reticulation (Figs. 64–70).

In the *clymene* group, *mainensis* is distinguished by the long, apically notched female subgenital plate and the apical bend of the aedeagal shaft. Externally, *mainensis* and *stewarti* males have large patches of spinules on the membrane of tergum 8, but size, shape, and arrangement of spines on the aedeagus is distinctive. Males of *cly-*

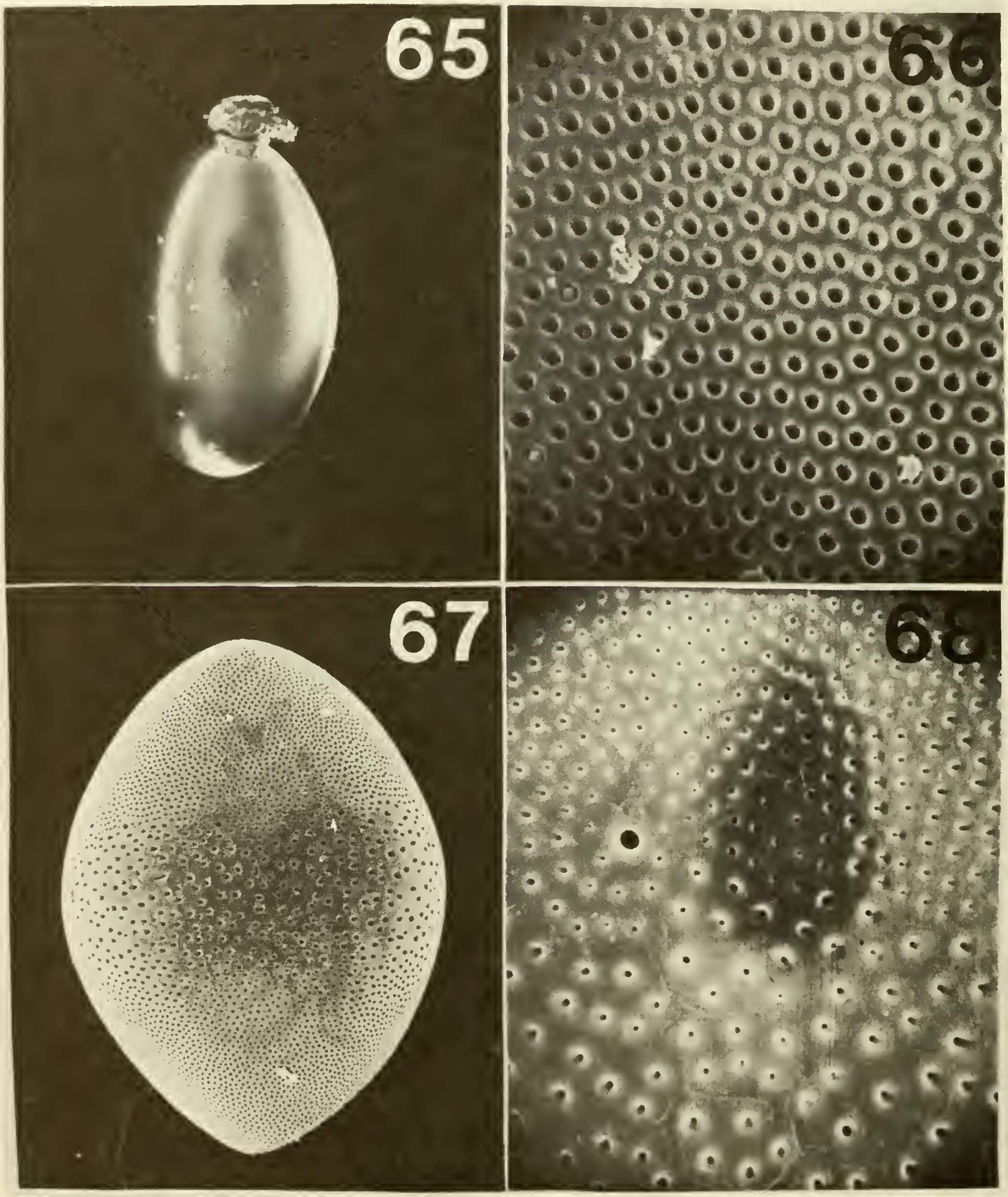


Figs. 56–59. SEM micrographs of eggs: 56, *Neoperla clymene*, 200x; 57, *N. clymene*, detail of polar end 500x; 58, *N. freytagi*, 260x; 59, *N. freytagi*, detail of polar end, 560x.



Figs. 60–64. SEM micrographs of eggs: 60, *Neoperla mainensis*, 215x; 61, *N. mainensis*, detail of collar, 1050x; 62, *N. mainensis*, detail of polar end, 1050x; 63, *N. stewarti*, 260x; 64, *N. catharae*, 400x.

mene and *freytagi* are externally similar, both having few or entirely lacking spinules on the membrane of tergum 8, but are separable by the absence of spinules on the aedeagal shaft in *clymene* and by the smaller number of spines of the apical aedeagal section in *freytagi*. Females are distinguished by the outline of subgenital plate, by the extent of spinulae in the spermatheca and by details of egg morphology (Figs. 56–63).



Figs. 65–68. SEM micrographs of eggs: 65, *Neoperla carlsoni*, 200x; 66, *N. carlsoni*, detail of chorion, 2000x; 67, *N. choctaw*, 200x; 68, *N. choctaw*, detail of chorion, 1000x.

ACKNOWLEDGMENTS

We are grateful to the following individuals and institutions for providing material used in this study: Dr. H. P. Brown, Univ. Oklahoma; Dr. H. R. Burke, Texas A & M Univ. (TAM); Dr. I. J. Cantrall, Univ. Michigan; Mr. P. H. Carlson, Clemson Univ. (PHC); Dr. M. Cather, Salt Lake City, Utah; Dr. W. R. Enns, Univ. Missouri (MU); Dr. O. S. Flint, Jr., U.S. National Museum (USNM); Dr. P. H. Freytag, Univ. Kentucky (PF); Mr. R. Gray, Dartmouth College (DC); Mr. B. Mather, Clinton, Mississippi (BM); Dr. W. L. Peters, Florida A & M Univ. (FAM); Dr. M. Prokop, Field Museum of Natural History (FMNH); Mr. A. V. Provonsha, Purdue Univ. (PU); Dr. R. Schick, California Academy of Sciences, Ms. J. Scott, Museum of Comparative Zoology (MCZ); Dr. F. F. Sherberger, Virginia Polytechnic Univ.; Dr. K. W. Stewart and Mr. S. W. Szczytko, North Texas State Univ. (NTSU); Ms. R. F. Surdick, Univ. Utah (UU); Mr. D. W. Webb, Illinois Natural History Survey (INHS); Dr. D. White, Univ. Oklahoma Biological Station; Dr. G. B. Wiggins, Royal Ontario Museum (ROM). Abbreviations for collections of the authors are BPS and RWB, respectively.

Special thanks are given to Walter R. Brown, Smithsonian Institution, Scanning Electron Microscope Laboratory, and to James V. Allen, Brigham Young University, Electron Microscope Laboratory, for help in photographing the *Neoperla* eggs. We also thank Mr. Stan Szczytko for assistance in preparing the SEM photograph of *N. catharae*.

LITERATURE CITED

BANKS, N. 1948. Notes on Perlidae. Psyche 55:113–130.

FRISON, T. H. 1935. The stoneflies, or Plecoptera, of Illinois. Bull. Illinois Natur. Hist. Surv. 20:281–471.

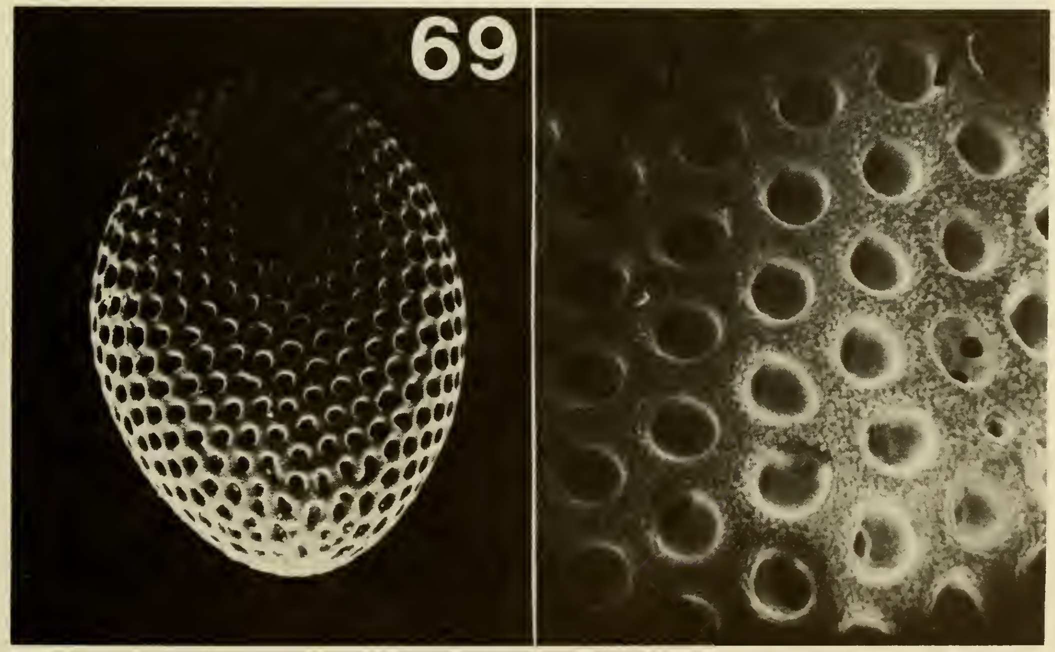
HYNES, H. B. N. 1952. The Neoperlinae of the Ethiopian region (Plecoptera: Perlidae). Trans. R. Entomol. Soc. Lond. 103:85–108.

KAWAI, T. 1967. Plecoptera (Insecta). *In*: Fauna Japonica. 211 p. Tokyo.

NEEDHAM, J. G. AND P. W. CLAASSEN. 1925. A monograph of the Plecoptera or stoneflies of America north of Mexico. Thomas Say Found. Entomol. Soc. Amer. 2:1–397.

RICKER, W. E. 1952. Systematic studies in Plecoptera. Indiana Univ. Pub., Sci. Ser. 18:1–200.

STEWART, K. W., B. P. STARK, AND T. HUGGINS. 1976.



Figs. 69–70. SEM micrographs of eggs: 69, *Neoperla gaufini*, 280x; 70, *N. gaufini*, detail of chorion, 1000x.

The stoneflies (Plecoptera) of Louisiana. Great Basin Nat. 36:366–384.

WU, C. F. 1938. Plecopterorum Sinensium: A monograph of the stoneflies of China (Order Plecoptera). 210 p. Peiping.

ZWICK, P. 1972. Die Plecopteren Pictets und Burmeisters, mit angaben über weitere arten (Insecta). Rev. Suisse Zool. 78:1123–1194.

_____. 1973a. Die Plecopteren-arten Enderleins (Insecta), Revision der typen. Ann. Zool. 30:471–507.

_____. 1973b. Entomological explorations in Ghana by Dr. S. Endrody-Younga 27. Notes on some species of *Neoperla* (Plecoptera). Folia Entomol. Hungarica 26:381–398.

MORPHOMETRY OF SCULPINS (*COTTUS*) IN THE CLEARWATER DRAINAGE, IDAHO

O. Eugene Maughan[1]

Abstract.— The morphometry of four Idaho species of Cottidae were compared. Pectoral ray counts allowed separation of *Cottus beldingi* and *C. confusus* from *C. bairdi* and *C. rhotheus* but not from each other. Preopercular armature also allowed identification of the same two groups of two species. Palatine tooth development generally allowed separation of each species as did body prickle development. Body ratios involving caudal peduncle depth allowed separation of *C. rhotheus* and *C. bairdi*. Development of lateral lines allowed differentiation of *C. rhotheus* from the other three species. A key was developed based on the combination of characters studied.

Geographic variation within the genus *Cottus* is a complex phenomenon that has hampered taxonomic comparisons for many years. Robins and Miller (1957) considered variation in the genus to be often haphazard. As a result of such variation, interpretation of species limits was difficult if not impossible. McAllister and Lindsey (1961) considered the freshwater sculpins of western North America to form an intriguing and perplexing mosaic of forms where convergent and divergent evolution confused the efforts of systematists to distinguish species and to discern relationships among species. Most systematists agreed that progress in understanding this genus depended on the accumulation of data describing variation of each form over the whole geographic range. Early attempts at cataloging information on geographic variation in cottids were accomplished by Bailey and Bond (1963), McAllister and Lindsey (1961), Robins and Miller (1957), and Koli (1969a).

In 1968-1970, I undertook an analysis of variation in sculpins within the Clearwater drainage system in northcentral Idaho. The objectives of the study were to collect data on variation that could serve as a contribution for evaluation of these species over their entire range.

Methods

Sculpins were collected with a backpack electroshocker from 114 locations in the Clearwater drainage (Maughan 1976). Ten fish of each species from each location were examined. Twenty-six primary and 36 derived characters were selected for analysis. The characters selected were from Robins and Miller (1957) and/or McAllister and Lindsey (1961). Morphometry followed the methods of Robins and Miller (1957) except that all paired fin counts were made from the right side of the fish (Maughan 1974). Sex was determined by examination of the genital papilla. Analysis was designed to determine the characters most useful to identify species, the extent of character variation within a species, and the degree of overlap among species.

Results

Four species of Cottidae were taken from the Clearwater drainage system. They were *Cottus bairdi* Bailey and Dimick, *C. beldingi* Eigenmann and Eigenmann, *C. confusus* Bailey and Bond, and *C. rhotheus* (Smith). Distributions overlapped for three of the species, but *C. confusus* was generally found further toward the headwaters than the other species (Maughan 1976).

---

[1] Department of Zoology, Washington State University, Pullman, Washington. Current address: Oklahoma Cooperative Fishery Research Unit, Department of Ecology, Fisheries, and Wildlife, Oklahoma State University, Stillwater, Oklahoma 74074.

Color.— Color and color pattern has been widely used as a taxonomic character for sculpins (Robins 1954, Williams and Robins 1970). Color of Clearwater cottids mimicked substrate color and showed no consistent pattern.

Spinous dorsal color.— A black blotch in the front and the rear of the spinous dorsal (*C. bairdi* species group) or a blotch only in the rear of the fin (*C. asper* species group), or a banded or a mottled fin (*C. carolinae* species group) has been used to separate species groups of sculpins (Bailey and Bond 1963). *Cottus bairdi, C. beldingi,* and *C. confusus* belong to the *C. bairdi* species group, whereas *C. rhotheus* belongs to the *C. carolinae* species group.

Clearwater *C. confusus* usually lacked black blotches on the fin; but, if blotches were present, they were found at both the front and the rear of the fin. Occasional fish had a black bar in the fin. A black blotch at the front and the rear of the fin, a black band through the fin, or a black blotch at the front and rear connected by a black band was the range of conditions in *C. beldingi. Cottus bairdi* had either a black bar through the fin or two black blotches connected by a black band. The fin was banded, mottled, or had scattered melanophores along the fin rays in *C. rhotheus.* Occasional fish had black-barred or black-blotched spinous dorsals. These fish were normally breeding males. When black blotches were present, they were usually present at both the front and the rear of the fin. The color of the spinous dorsal overlapped in all the species studied and did not allow separation of species.

Dorsal saddles.— The number of dorsal saddles has been used to identify cottid species (Bailey and Dimick 1949). The basal number is six saddles: two under the spinous dorsal, three under the soft dorsal, and one crossing the caudal peduncle. Occasionally, there are four saddles under the soft dorsal.

Five or six saddles (mean 4.7, S.E. 1.4) were usually present in *C. confusus.* The saddle crossing the caudal peduncle was generally absent. Usually the first spinous dorsal saddle was also absent from South Fork and North Fork Clearwater fishes. Five, six, or seven saddles (mean 5.3, S.E. 1.7) were present in *C. beldingi. C. bairdi* usually had six dorsal saddles (mean 5.9, S.E. 0.4), but a seventh saddle was sometimes present. *Cottus rhotheus* usually had fewer saddles (mean 4.8, S.E. 0.6) than the other species except *C. confusus.* The first spinous dorsal saddle and the second soft dorsal saddle were commonly absent in *C. rhotheus,* with the caudal peduncle saddle sometimes absent. The saddles ran cephalad at about 60 degree angles to the horizontal axis in *C. rhotheus* but were perpendicular to the horizontal axis in the other three species.

Palatine teeth.— The development of palatine teeth has been widely used to separate species and species groups of sculpins. The variability of this character is not generally extensive, although some variability is encountered.

Cottus confusus had been reported to have weakly developed palatine teeth and show very little variability in the development of palatine teeth. Bailey and Bond (1963) examined over 500 specimens of this species and found only one individual that lacked palatine teeth. Weakly developed palatine teeth were present in my specimens except some from Squaw Creek (tributary to the Lochsa) and from the upper Selway. Approximately 70 percent of the specimens from the headwaters of Squaw Creek lacked palatine teeth, and 10 percent had teeth only on one side. All specimens at this location had the axial prickle pattern typical of *C. confusus.* About 20 percent of the fish at the mouth of Squaw Creek were without palatine teeth, and 30 percent had teeth on only one side. Two fish from the upper Selway River lacked teeth, and two fish had teeth only on one side.

Cottus beldingi normally lacks palatine teeth, although the type specimen had teeth (Eigenmann and Eigenmann 1891). All individuals from the Clearwater lacked palatine teeth except for 3 percent of the fish from Lapwai Creek, which had palatine teeth on one or both sides. Specimens of *C. beldingi* from Lolo Creek near Musselshell Ranger Station lacked palatine teeth but one individual had body prickles. Possibly, this population was the result of hybridization of *C. beldingi* and *C. confusus.*

The palatine teeth in *C. bairdi* and *C. rhotheus* from the Clearwater were extensively developed. *Cottus rhotheus* usually had the palatine and vomerine teeth conjoined, whereas *C. bairdi* showed a slight separation between the tooth patches.

The presence or absence of palatine teeth plus the degree of development were sufficient to separate the four species from the Clearwater, with the exceptions discussed above.

Sex.— The number of males was slightly greater than the number of females taken in all species but was not significantly different from a one-to-one ratio. Bailey (1952) and Smyly (1957) found that males were more abundant in deeper water, and females were more abundant in shallow waters (less than 18 inches). The slight propensity toward males in my collection may reflect a tendency to sample deeper waters, although an attempt was made to sample all habitats with equal intensity.

Meristic characters.— Meristic or countable characters have long been used for systematic studies. Pelvic fin rays, pectoral fin rays, anal fin rays, soft dorsal fin rays, and spinous dorsal fin rays were counted in this study (Table 1). Values obtained varied only slightly from values previously reported (*C. bairdi*, Bailey and Dimick 1949; *C. confusus*, Bailey and Bond 1963; *C. beldingi*, Eigenmann and Eigenmann 1891, Hubbs and Schultz 1932; and *C. rhotheus*, Smith 1882, Bailey and Dimick 1949). However, 30 percent of the specimens of *C. beldingi* did have pelvic ray counts of 1, 3.

Counts would not separate the four Clearwater species. The mean number of pectoral rays generally separated the species into two groups of two species, but there was some overlap in ranges. Other counts showed slight differences in modes, but these differences were insignificant when compared to the ranges.

Body proportions.— Thirty-six proportions were analyzed to determine whether any single proportion would allow separation of species (Table 2). Several proportions allowed division of fish into overlapping groups, but only ratios involving caudal peduncle depth allowed identification of *C. rhotheus* and *C. bairdi*. *Cottus confusus* and *C. beldingi* were not separated from each other by any proportions.

Body prickles.— The degree of body prickling is a character used in cottid taxonomy (Robins and Miller 1957, Koli 1969b, Oliva and Hensel 1962), although variability is commonly related to habitat and age (Robins and Miller 1957, Koli 1969a, Krejsa 1965). The prickling pattern was typical for most representatives of all species (Table 3) (*C. beldingi*, Eigenmann and Eigenmann 1891; *C. confusus*, Bailey and Bond 1963; *C. bairdi*, Bailey and Dimick 1949; *C. rhotheus*, Bailey and Dimick 1949). Exceptions were found since one specimen of *C. beldingi* had two prickles in the axial position and the prickling pattern of larger specimens of *C. rhotheus* approached the condition typical of *C. bairdi*. These specimens of *C. rhotheus* may represent older fish that have begun to resorb prickles since prickle resorption with maturity is apparently a common phenomenon in other species of the genus (Krejsa 1965, Koli 1969a).

The prickling pattern within each of the four species was relatively constant within the Clearwater specimens. The greatest variability occurred in *C. rhotheus*, but this variation was related to size and not to location.

Preopercular-mandibular canal.— The preopercular-mandibular canals are composed of a preopercular canal and a mandibular

Table 1. Mean number of fin rays in each of four species of Clearwater Drainage cottids.

Species	Sample size	Pectorals		Anal		Soft dorsal		Spinous dorsal	
		Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
C. confusus	219	13.3	0.6	13.0	0.7	17.2	0.7	8.1	0.3
C. beldingi	546	14.0	0.5	11.9	0.5	17.2	0.7	7.6	0.9
C. bairdi	227	15.6	0.5	12.6	0.6	17.0	0.6	7.7	0.4
C. rhotheus	316	16.0	0.5	12.1	0.5	16.1	0.6	8.1	0.5

TABLE 2. Mean values for body ratios of each of 4 species of cottids. R_1 = standard length/total length, R_2 = head length/total length, R_3 = longest soft dorsal ray/total length, R_4 = longest soft dorsal ray/total length, R_5 = body depth/total length, R_6 = caudal peduncle depth/total length, R_7 = mouth width/total length, R_8 = head width/total length, R_9 = head length/standard length, R_{10} = longest soft ray/standard length, R_{11} = longest spinous ray/standard length, R_{12} = body depth/standard length, R_{13} = caudal peduncle depth/standard length, R_{14} = mouth width/standard length, R_{15} = head width, standard length, R_{16} = longest soft ray/head length, R_{17} = longest spinous ray/head length, R_{18} = body depth/head length, R_{19} = caudal peduncle depth/head length, R_{20} = mouth width/head length, R_{21} = head width/head length, R_{22} = longest soft ray/head width, R_{23} = longest spinous ray/head width, R_{24} = body depth/head width, R_{25} = caudal peduncle depth/head width, R_{26} = mouth width/head width, R_{27} = longest soft ray/mouth width, R_{28} = longest spinous ray/mouth width, R_{29} = body depth/mouth width, R_{30} = caudal peduncle depth/mouth width, R_{31} = longest soft ray/body depth, R_{32} = longest spinous ray/body depth, R_{33} = caudal peduncle depth/body depth, R_{34} = longest soft ray/caudal depth, R_{35} = longest spinous ray/caudal peduncle depth, and R_{36} = longest spinous ray/longest soft ray.

	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}	R_{11}	R_{12}	R_{13}*	R_{14}	R_{15}	R_{16}	R_{17}	R_{18}
C. bairdi N=219	.81	.28	.13	.09	.19	.06	.19	.26	.32	.17	.11	.24	.08	.23	.36	.48	.33	.69
C. beldingi N=546	.81	.26	.12	.07	.18	.08	.16	.24	.30	.15	.09	.22	.10	.20	.31	.46	.27	.69
C. confusus N=227	.81	.24	.12	.08	.17	.07	.15	.22	.26	.15	.10	.21	.09	.19	.29	.49	.32	.69
C. rhotheus N=219	.81	.29	.14	.09	.19	.05	.21	.28	.35	.17	.11	.23	.06	.26	.37	.47	.30	.64

	R19	R20	R21	R22	R23	R24	R25*	R26	R27	R28	R29	R30*	R31	R32	R33*	R34	R35*	R36
C. bairdi N=219	.23	.67	1.05	.47	.32	.66	.22	.64	.74	.50	1.0	.34	.70	.48	.33	2.14	1.47	.69
C. beldingi N=546	.31	.62	.96	.48	.28	.72	.32	.64	.76	.44	1.1	.51	.68	.40	.45	1.50	.88	.59
C. confusus N=227	.30	.63	.99	.49	.32	.70	.31	.64	.78	.51	1.1	.48	.71	.46	.44	1.62	1.06	.66
C. rhotheus N=219	.17	.73	1.03	.45	.29	.62	.17	.70	.65	.41	.89	.24	.73	.46	.27	2.75	1.75	.64

*Allow separation of species.

canal overlying each mandible and each preopercular bone, respectively. The pores of these canals are the openings of the preopercular-mandibular cephalic sensory systems. The head pore system of the genus *Cottus* has been widely used in systematic studies (Robins and Miller 1957, McAllister and Lindsey 1961, Robins 1954, 1961, McAllister 1964, 1968). Variability is generally in the mental pore condition, with either the two mental pores fused into a single median chin pore or, more often, the median chin pore split into two mental pores (McAllister 1968).

The Clearwater cottids usually had two mental pores and double postmaxillary pores. This condition gave 11 pores on each side of the preopercular-mandibular canal (Tables 4 and 5). Variation from this condition resulted from fusion of the mental pores, absence or addition of one post-

TABLE 3. Extent of body prickles on each of four species of cottids.

Species	Sample size	Mean range	Mean*	S.E.
C. confusus	219	2.0–2.4	2.1	0.2
C. beldingi	546	1.0– 1.2	1.0	0.1
C. bairdi	227	4.0– 8.0	6.0	2.1
C. rhotheus	316	11.0–15.0	13.1	2.2

*Based on a scale of 1 to 15. One indicates prickles absent and 15 indicates entire body covered with prickles.

maxillary pore, absence of the third pore from the chin midline, an additional pore above the first preopercular spine, or a combination of these factors. Pores other than those mentioned were occasionally absent.

Variability in number of preopercular-mandibular pores was high only in South Fork Clearwater *C. confusus.* About 73 percent of the counts differed from 11-11 and ranged from 12-12 to 9-9. The counts were symmetrical (10-10, 9-9, 9-1-9) in about 64 percent of the variant individuals. The 10-10 counts resulted from nearly 71 percent of the variant fishes having single postmaxillary pores. The postmaxillary pores were double on one side and single on the other in another 21 percent of the variant fishes. The 9-9 and 9-1-9 counts had a more variable basis. The 9-9 condition generally resulted from single postmaxillary pores plus the absence of another pore from each side (commonly the third pore from the chin midline). The 9-1-9 counts were usually a result of fusion of the mental pores into a single median pore plus single postmaxillary pores.

Lateral Line.— The degree of completeness of the lateral line is sometimes useful as a taxonomic character (Robins and Miller 1957, Koli 1969a, McAllister and Lindsey 1961). The lateral line was recorded in this study as complete, incomplete, or interrupted and a number given the position at which the complete line terminated (Table 6). The lateral line in all four species generally extended caudad above the axial line to just slightly behind the extent of the soft dorsal fin. At this point, the lateral line or its remnant was deflected downward to the axial line. If the line were still present beyond this point, it followed the axial line to the hypural plate.

Bailey and Bond (1963) found that the lateral line was generally incomplete or interrupted in *C. confusus.* Specimens from the Clearwater generally had the lateral line ending under the last few soft dorsal rays or slightly behind the extent of the soft dorsal. However, 23 percent of the specimens had the lateral line interrupted. There were usually short segments of lateral line along the axial line anterior to the hypural plate in these specimens.

Cottus beldingi usually had the lateral line incomplete or interrupted with 15 percent of all individuals collected having interrupted lateral lines, and less than 5 having complete lateral lines. However, 70-80 percent of the fish from Elk Creek had complete lateral lines.

Cottus bairdi usually has a complete or nearly complete lateral line (Bailey and

Table 5. Development of postmandibular pore for each of four species of cottids.

Species	Sample size	Mean range	Mean*	S.E.
C. confusus	219	4.0–8.2	5.2	2.0
C. beldingi	546	4.0–6.6	4.2	0.9
C. bairdi	227	3.9–4.3	4.0	0.1
C. rhotheus	316	4.0–4.7	4.1	0.5

*Based on a scale of 1 through 12. One indicates postmandibular pores were triple on both sides. Twelve indicates postmandibular pores absent on both sides. Four indicates postmandibular pores double on both sides.

Table 6. Mean extent of lateral line for each of four species of cottids.

Species	Sample size	Mean range	Mean*	S.E.
C. confusus	219	11.1–18.0	16.0	2.3
C. beldingi	546	10.3–20.3	17.6	1.8
C. bairdi	227	17.3–21.0	19.4	1.6
C. rhotheus	316	18.9–21.0	20.8	1.1

*Based on a scale of 1 to 21. One indicates lateral line ends under first soft dorsal ray. Twenty-one indicates line ends at hypural plate.

Table 4. Mean number of preopercular-mandibular canal pores for each of four species of cottids.

Species	Sample size	Right mean range	Left mean range	Right mean	Left mean	Right S.E.	Left S.E.
C. confusus	219	9.7–11.2	9.8–11.2	10.7	10.7	0.6	0.6
C. beldingi	546	10.5–11.3	10.2–11.7	10.9	10.9	0.3	0.4
C. bairdi	227	10.8–11.3	10.7–11.2	11.0	11.0	0.2	0.3
C. rhotheus	316	10.2–11.1	10.4–11.1	10.9	10.9	0.4	0.3

Dimick 1949). The lateral line usually ended just anterior to the hypural plate in Clearwater specimens but was complete in about 18 percent of the individuals.

Cottus rhotheus generally has a complete lateral line except in very small individuals (Bailey and Dimick 1949). The lateral line was complete or nearly complete in all Clearwater specimens.

Cottus rhotheus could generally be distinguished from the other species by the completeness of the lateral line, but the other species could not be distinguished from each other. In all species the development of the lateral line was related to age, with greater lateral line development in larger, mature individuals rather than in smaller fish.

Preopercular Armature.— The number of preopercular spines is constant enough in some species of cottids to be useful as a taxonomic character. In other species, this character is highly variable (Bailey and Bond 1963, Robins and Miller 1957).

Cottus beldingi was reported to have a single preopercular spine (Eigenmann and Eigenmann 1891, Hubbs and Schultz 1932). This character varied from one to more than three spines in the Clearwater material. The mode for the species was one spine plus variable combinations of bumps, but the median value was more than two spines. Variability was high at all locations.

Variability in spinous condition was also high in *C. confusus*. *Cottus confusus* from the Lochsa, Selway, and North Fork Clearwater usually had two or three spines with various combinations of bumps. Few individuals with only one spine (16 percent) were seen. In contrast, individuals from the South Fork Clearwater had no spine, a single spine, or a single spine plus weakly developed bumps.

Variation in the preopercular armature of *C. rhotheus* and *C. bairdi* was relatively slight. Most specimens of *C. rhotheus* had three spines plus bumps or four spines. Typically, *C. bairdi* had three spines and either no bumps or weakly developed bumps.

Species did not differ sufficiently in preopercular armature to allow identification, but development of the preopercular armature did allow identification of two groups of two species (Table 7).

TABLE 7. Development of projections from the preopercular bone for each of four species of cottids.

Species	Sample size	Mean range	Mean*	S.E.
C. confusus	219	8.0–28.9	24.3	6.5
C. beldingi	546	15.9–27.9	23.4	5.8
C. bairdi	227	30.6–34.5	32.2	1.7
C. rhotheus	316	32.4–34.7	33.2	1.2

*Based on a scale of 1 to 35. One indicates no projections on preopercular bone. Thirty-five indicates four spines on preopercular bone.

CONCLUSIONS

Body color was variable within and among species and was generally related to substrate color or breeding condition.

No single meristic character allowed differentiation among these species. Pectoral ray counts allowed separation into two groups of two species but did not separate the species within the groups. *Cottus beldingi* and *C. confusus* usually had 13 or 14 pectoral rays, whereas *C. bairdi* and *C. rhotheus* usually had 15 or 16 rays.

The development of palatine teeth usually separated the four species, but unusual specimens could not be identified with this character. *Cottus beldingi* generally lacked palatine teeth, *C. confusus* usually had weakly developed palatine teeth, *C. bairdi* had well-developed palatine teeth with a small separation between the vomerine and palatine teeth, and *C. rhotheus* had the vomerine and palatine teeth cojoined and well developed.

Most body proportions failed to separate species. However, ratios involving caudal peduncle depth usually separated *C. rhotheus* and *C. bairdi* from other species and from each other.

The development of body prickles generally separated the four species. *Cottus beldingi* lacked prickles, *C. confusus* had a small patch of axial prickles, *C. bairdi* had axial prickles plus a row of prickles above the lateral line, and *C. rhotheus* had prickles over most of the body. However, within each species, some fish showed the condition typical of one of the other species.

Larger *C. rhotheus* had apparently begun to resorb prickles and approximated the condition typical of *C. bairdi.*

The development of the lateral line usually separated *C. rhotheus* from the other species if adult specimens were used. The lateral line was usually complete in *C. rhotheus* and interrupted or incomplete in the other species.

The preopercular armature was usually better developed in *C. bairdi* and *C. rhotheus* than in *C. beldingi* or *C. confusus.* The two groups of two species could not be separated using this character.

No single character allowed separation among the species of cottids from the Clearwater. However, the characters studied could, when used in combination, give reasonable accuracy in identification.

Key to the Clearwater Drainage *Cottus*

1. Palatine teeth generally present. Prickles developed at least in the axial position. Lateral line variable 2

Palatine teeth usually absent; if present, commonly only developed on one side. Body naked. Lateral line interrupted or incomplete, rarely complete. Found in the main river and lower tributaries .... *C. beldingi*

2(1). Prickles covering most of the body except in large specimens. Lateral line usually complete. Palatine teeth well developed, usually conjoined with the vomerine teeth. Caudal peduncle to total length ratio about 0.05. Skin over the eye nubbly. Body saddles extending cephalad at an angle to the long axis of the body. Restricted to the main river and the larger tributaries .... *C. rhotheus*

Prickles restricted to an axial patch or an axial patch plus a bar paralleling the lateral line. Palatine teeth usually present. Lateral line usually incomplete, rarely complete 3

3(2). Prickles restricted to an axial patch. Palatine teeth usually present and weakly developed, sometimes absent in restricted locations. Lateral line usually ending under the last few soft dorsal rays, sometimes interrupted, with pores on the axial line just anterior to the hypural plate. Caudal peduncle to total length ratio about 0.07. Usually 13 or 14 pectoral rays. Restricted to the headwater areas at the upper portions of the drainage .... *C. confusus*

Prickles usually an axial patch plus a bar above the lateral line. Palatine teeth strongly developed with only a slight separation between palatine and vomerine tooth patches. Lateral line usually incomplete, ending just anterior to the hypural plate, sometimes complete. Caudal peduncle to total length ratio about 0.06. Usually 15 to 16 pectoral rays. Skin over eye not nubbly. Dorsal saddles perpendicular to the long axis of the body. Restricted to the main river and larger tributaries .... *C. bairdi*

ACKNOWLEDGMENTS

Dr. Donald Chapman, Cooperative Fishery Research Unit, University of Idaho, suggested the study, and Dr. I. O. Buss, Department of Zoology, Washington State University, guided it to completion. Dr. Carl E. Bond, Professor of Fisheries, Oregon State University, gave advice and encouragement and verified species identifications. Dr. Richard Wallace, Department of Biology, University of Idaho, and Dr. Herbert Eastlick, Dr. Charles McNeil, Dr. Vincent Schultz, and Dr. Robert Jonas, Department of Zoology, Washington State University, reviewed the work. Maurice O. Nyquist, Larry Gibson, and M. Gary Wickham assisted in collecting, and the Idaho State Fish and Game Department supplied necessary collecting permits. The U.S. government (NDEA Grant) and Washington States University provided funding for the study. The

Department of Zoology, Washington State University, also provided space, equipment, and supplies for the study. The Environmental Institute, Oklahoma State University, provided funds for publication.

LITERATURE CITED

Bailey, J. E. 1952. Life history and ecology of the sculpin *Cottus bairdi punctulatus* in southwestern Montana. Copeia 1952:243–255.

Bailey, R. M., and C. E. Bond. 1963. Four new species of freshwater sculpins, genus *Cottus*, from western North America. Occasional Papers 643:1–27. Museum of Zoology, University of Michigan.

Bailey, R. M., and M. F. Dimick. 1949. *Cottus hubbsi*, a new cottid fish from the Columbia River in Washington and Idaho. Occasional Papers 513:1–18. Museum of Zoology, University of Michigan.

Eigenmann, C. H., and R. S. Eigenmann. 1891. *Cottus beldingi* sp. nov. Amer. Nat. 25:1132.

Hubbs, C. L., and L. P. Schultz. 1932. *Cottus tubulatus*, a new sculpin from Idaho. Occasional Papers 242:1–9. Museum of Zoology, University of Michigan.

Koli, L. 1969a. Geographic variation of *Cottus gobio* L. (Pisces, Cottidae) in northern Europe. Ann. Zool. Fenn. 6(4):353–390.

______. 1969b. The spiniform armature of some palearctic freshwater species of the family Cottidae. Ann. Zool. Fenn. 6(4):428–430.

Krejsa, R. J. 1965. The systematics of the prickly sculpin, *Cottus asper*; an investigation of genetic and nongenetic variation within a polytypic species. Ph.D. dissertation. University of British Columbia, Vancouver, British Columbia.

McAllister, D. E. 1964. Distinguishing characters for the sculpins, *Cottus bairdi* and *Cottus cognatus*, in eastern Canada. J. Fish. Res. Bd. Canada 21:1339–1342.

______. 1968. Mandibular pore pattern in the sculpin family Cottidae. Nat. Mus. Canada Bull. 223:58–59.

McAllister, D. E., and C. C. Lindsey. 1961. Systematics of the freshwater sculpins (*Cottus*) of British Columbia. Nat. Mus. Canada Bull. 172:66–89.

Maughan, O. E. 1974. Paired fin ray counts of several species and populations of the genus *Cottus*. Copeia 1974:980.

______. 1976. A survey of fishes of the Clearwater River. Northwest Sci. 50(2):76–86.

Oliva, O., and K. Hensel. 1962. Studies on sculpins (*Cottus gobio* L.) from the river Pruth. Vestnik. Cechoslov. Spolecnosti Zool. 36:244–249.

Robins, C. R. 1954. A taxonomic revision of the *Cottus bairdi* and *Cottus carolinae* species groups in eastern North America. Ph.D. dissertation. Cornell University, Ithaca, New York.

______. 1961. Two new cottid fishes from the fresh waters of the eastern United States. Copeia 1961:305–315.

Robins, C. R., and R. R. Miller. 1957. Classification, variation, and distribution of the sculpins, genus *Cottus*, inhabiting Pacific slope waters in California and southern Oregon with a key to the species. Calif. Fish and Game 43:213–233.

Smith, R. 1882. Description of a new species of Uranidea (*Uranidea rhotheus*) from the Spokane River, Washington territory. Proc. U.S. Nat. Mus. 1882:347–348.

Smyly, W. J. P. 1957. The life history of the bullhead or miller's thumb (*Cottus gobio* L.). Proc. Zool. Soc. London 128(3):431–453.

Williams, J., and C. R. Robins. 1970. Variation in populations of the fish *Cottus carolinae* in the Alabama River system with description of a new subspecies from below the fall line. Amer. Midl. Nat. 83(2):368–381.

CORRECTION: *RHAMNUS CATHARTICA* L. IS NOT *PRUNUS NIGRA* AIT. FROM ALBERTA

R. Keith Shaw[1]

Abstract.— The plant previously reported from Alberta as Canada Plum (*Prunus nigra Ait.*) flowered and is now recognized European Buckthorn (*Rhamnus cathartica* L.).

The report of Canada Plum (*Prunus nigra* Ait.) in Alberta (Cody and Shaw 1973, Shaw 1976) was based on material collected without flowers or fruit from south Alberta. The preliminary identification was made from floral manuals only, with later verification through comparison with known *Prunus nigra* material at the Vascular Plant Herbarium of the Canada Department of Agriculture, Ottawa.

Several years later these south Alberta plants flowered and fruited. Much to my dismay, it was not *Prunus nigra,* but an adventive species hitherto unreported for Alberta to which *Prunus nigra* bears an uncanny resemblance, *Rhamnus cathartica* L., the European Buckthorn. This species was introduced from Europe and is now found growing wild as a coarse shrub or small tree in the valley of Lee Creek at Cardston, Alberta. Two ornamental plantings are now also known for the town of Cardston.

When the plants are in flower or fruit no real difficulty is encountered in correctly identifying European Buckthorn, which has flowers small, greenish, perfect, regular, perigynous with an annular disk; sepals 4; petals much reduced to wanting; stamens 4, inserted on the disk opposite the rudimentary petals; pistil 1, the ovary inserted in the disk, 4-loculed, each locule 1-seeded; fruit juicy, berrylike, and bitter.

However, a comparison of vegetative characteristics will show how readily a person unfamiliar with these two species might make an error:

Rhamnus cathartica	*Prunus nigra*
European Buckthorn	Canada Plum
spine-tipped branchlets	thornlike twigs
no terminal bud	no terminal bud
toothed leaves, thin and fragile	double-toothed leaves, thin and fragile
leaves dark green above, lighter below	leaves dull dark green above, paler beneath
leaves tend toward opposite or clustered	leaves clustered
leaf margin glandular	leaf margin glandular
scaly winter buds	scaly winter buds
twigs slender, reddish-brown	twigs slender, smooth, reddish-brown
bark smooth, dark greyish-brown, becoming scaly with age	bark black with greyish lenticels, splitting vertically, scaly with age
short, crooked trunk divided at or just above ground	short, crooked trunk divided at or just above ground
crown irregular; slender zig-zag branches	crown narrow and flat-topped; slender, twisted, zig-zag branches
small tree or large shrub	small tree

I regret any inconvenience this erroneous report of *Prunus nigra* has caused. I will gladly supply herbarium specimens of south Alberta *Rhamnus cathartica* on request.

Literature Cited

Cody, W. J., and K. Shaw. 1973. Canada Plum in southwestern Alberta. Blue Jay 31:217–219.

Shaw, R. K. 1976. A taxonomic and ecologic study of the riverbottom forest on St. Mary River, Lee Creek, and Belly River in southwestern Alberta, Canada. Great Basin Nat. 36:243–271.

---

[1] Box 364, Cardston, Alberta. TOK OKO

NOTICE TO CONTRIBUTORS

Original manuscripts in English pertaining to the biological natural history of western North America and intended for publication in the *Great Basin Naturalist* should be directed to Brigham Young University, Stephen L. Wood, Editor, *Great Basin Naturalist*, Provo, Utah 84602. Those intended for the *Great Basin Naturalist Memoirs* should be similarly directed, but these manuscripts are not encumbered by a geographical restriction.

Manuscripts. Two copies of manuscripts are required. They should be typewritten, double spaced throughout on one side of the paper, with margins of at least one inch on all sides. Use a recent issue of either journal as a format, and the *Council of Biology Editors Style Manual, Third Edition* (AIBS 1972) in preparing the manuscript. An abstract, about 3 percent as long as the text, but not exceeding 200 words, written in accordance with Biological Abstracts guidelines, should precede the introductory paragraph of each article. Authors may recommend one or two reviewers for their article. All manuscripts receive a critical peer review by specialists in the subject area of the manuscript under consideration.

Manuscripts that are accepted and that are less than 100 printed pages in length will automatically be assigned to the *Great Basin Naturalist*. Those manuscripts larger than 100 printed pages in length will be considered for the *Memoirs* series.

Illustrations and Tables. All illustrations and tables should be made with a view toward having them appear within the limits of the printed page. Illustrations that form part of an article should accompany the manuscript. Illustrations should be prepared for reduction by the printer to either a single-column (2 5/8 inches) or double-column (5 1/2 inches) width, with the length not exceeding 7 1/2 inches.

Costs Borne by Contributor. Contributors to the *Great Basin Naturalist* should be prepared to donate from $10 to $30 per printed page toward publication of their article (in addition to reprint costs outlined in the schedule below). Authors publishing in the *Great Basin Naturalist Memoirs* may be expected to contribute $35 per printed page in addition to the cost of printed copies they purchase. No printed copies are furnished free of charge. A price list for reprints and an order form are sent with the galley proof to contributors.

Reprint Schedule of the *Great Basin Naturalist*

	2 pp.	4 pp.	6 pp.	8 pp.	10 pp.	12 pp.	Each additional 2 pp.
100 copies	$20	$24	$28	$32	$36	$40	$4
200 copies	28	32	36	40	44	48	
300 copies	36	40	44	48	52	56	

Great Basin Naturalist Memoirs

No. 1 The birds of Utah. By C. L. Hayward, C. Cottam, A. M. Woodbury, H. H. Frost. $10.

No. 2 Intermountain biogeography: A symposium. By K. T. Harper, J. L. Reveal, et al. $15.

TABLE OF CONTENTS

Endangered and threatened plants of Utah: A reevaluation. Stanley L. Welsh 1

Plants of Navajo National Monument. J. D. Brotherson, G. Nebeker, M. Skougard, and J. Fairchild 19

Environmental interaction in summer algal communities of Utah Lake. Mark C. Whiting, Jack D. Brotherson, and Samuel R. Rushforth 31

Basidiomycetes that decay junipers in Arizona. II. R. L. Gilbertson and J. P. Lindsey 42

Pinus longaeva in the Stansbury Mountains, Utah. P. A. Kay and C. G. Oviatt 49

Differential parasitism of *Peromyscus maniculatus* and *Peromyscus truei* by *Cuterebra* larvae. Jeffrey B. Llewellyn 51

An annotated list of the aquatic insects of southeastern Idaho, Part III. Ephemeroptera. Robert L. Newell and G. Wayne Minshall 55

Observations on the prey and nests of seven species of *Cerceris* (Hymenoptera: Sphecidae). Howard E. Evans and William L. Rubink 59

Vertebrate fauna of a radioactive leaching pond complex in southeastern Idaho. Douglas K. Halford and Jere B. Millard 64

New synonymy, new species, and taxonomic notes of North American *Pityophthorus* (Coleoptera: Scolytidae), Part III. Donald E. Bright 71

Fluctuation of a marsh habitat and the reproductive strategy of the Yellow-headed Blackbird. Roger J. Lederer 85

Hosts of juniper mistletoe at Walnut Canyon National Monument, Arizona. Frank G. Hawksworth and Robert L. Mathiasen 89

Allelopathic effects of Bur Buttercup tissue on germination and growth of various grasses and forbs *in vitro* and in soil. Bruce A. Buchanan, K. T. Harper, and Neil C. Frischknecht 90

New species of Nearctic *Neoperla* (Plecoptera: Perlidae), with notes on the genus. Bill P. Stark and Richard W. Baumann 97

Morphometry of sculpins (*Cottus*) in the Clearwater drainage, Idaho. O. Eugene Maughan 115

Correction: *Rhamnus cathartica* L. is not *Prunus nigra* Ait. from Alberta. R. Keith Shaw 123

THE GREAT BASIN NATURALIST

Volume 38 No. 2 June 30, 1978 Brigham Young University

S-G 786.8

MUS. COMP. ZOOL.
LIBRARY
JAN 22 1979
HARVARD
UNIVERSITY

GREAT BASIN NATURALIST MEMOIRS

Editor. Stephen L. Wood, Department of Zoology, Brigham Young University, Provo, Utah 84602.

Editorial Board. Kimball T. Harper, Botany; Wilmer W. Tanner, Life Science Museum; Stanley L. Welsh, Botany; Clayton M. White, Zoology.

Ex Officio Editorial Board Members. A. Lester Allen, Dean, College of Biological and Agricultural Sciences; Ernest L. Olson, Director, Brigham Young University Press, University Editor.

The *Great Basin Naturalist* was founded in 1939 by Vasco M. Tanner. It has been published from one to four times a year since then by Brigham Young University, Provo, Utah. In general, only previously unpublished manuscripts of less than 100 printed pages in length and pertaining to the biological natural history of western North America are accepted. The *Great Basin Naturalist Memoirs* was established in 1976 for scholarly works in biological natural history longer than can be accommodated in the parent publication. The *Memoirs* appears irregularly and bears no geographical restriction in subject matter. Manuscripts are subject to the approval of the editor.

Subscriptions. The annual subscription to the *Great Basin Naturalist* is $12 (outside the United States $13). The price for single numbers is $4 each. All back numbers are in print and are available for sale. All matters pertaining to the purchase of subscriptions and back numbers should be directed to Brigham Young University, Life Science Museum, Provo, Utah 84602. The *Great Basin Naturalist Memoirs* may be purchased from the same office at the rate indicated on the inside of the back cover of either journal.

Scholarly Exchanges. Libraries or other organizations interested in obtaining either journal through a continuing exchange of scholarly publications should contact the Brigham Young University Exchange Librarian, Harold B. Lee Library, Provo, Utah 84602.

Manuscripts. All manuscripts and other copy for either the *Great Basin Naturalist* or the *Great Basin Naturalist Memoirs* should be addressed to the editor as instructed on the back cover.

11-78 650 34941

ISSN 0017-3614

The Great Basin Naturalist

Published at Provo, Utah, by
Brigham Young University

ISSN 0017-3614

Volume 38 June 30, 1978 No. 2

KAIPAROWITS FLORA

Stanley L. Welsh[1], N. Duane Atwood,[2]
and Joseph R. Murdock[1]

Abstract.— The paper presents an annotated list of 851 taxa in 358 genera and 80 families. Threatened and endangered plants are enumerated.

Diversity of vegetative types in the Kaiparowits Basin is reflected in the large number of species present in that basin.[3] Elevational differences of 2,680 m from the low point at Lee's Ferry to the high point on the summit of Navajo Mountain accounts for some of the diversity of plant species. Substrate differences in the basin range from saline clays through all the common particle sizes to boulders and slickrock. The focus of the basin is the Colorado River canyon into which all of the drainages of the basin pour their loads, and plants have followed this feature as a major migrational pathway. This is true of the major communities of plants in the vicinity, and is especially so for those at lower elevations.

Lower elevational species are representative of more southern distributional patterns which find the hot dry canyon and the lower features compatible with their needs. Middle and higher elevation species are more representative of boreal vegetation. The two types intertongue in the lower middle elevations where soil conditions are compatible. Specific soil types tend to be occupied by characteristic kinds of vegetation, that which is sufficiently specialized as to survive and compete on the unusual soils. This is demonstrated on the saline clays of such formations as the Tropic Shale which forms the benchland below the Nipple Bench-Smoky Mountain uplands.

Amounts of precipitation are roughly correlatable with elevation, and the low amounts at low elevations are reflected in the kinds of plants which can grow there. This is also true for the middle and higher elevations. Vegetation and the diversity of species change from one rainfall regimen to another. Where water is available on a permanent basis, such as along streams or in hanging gardens, the plant assemblage changes drastically when contrasted to that in nearby arid lands. All of these habitat types combine to set the Kaiparowits Basin apart as a unique entity.

The following annotated list of vascular plants contains some 851 taxa (822 species and 29 infraspecific units) placed in 358 genera and 80 families. They represent diverse phytogeographical provinces from cold to warm temperate and even subtropical regions of this hemisphere. They are recognized as belonging to montane forest, ponderosa pine, juniper-pinyon, sagebrush, salt-desert shrub, warm desert shrub, riparian, and hanging garden communities.

---

[1] Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602.

[2] Bureau of Land Management, Cedar City, Utah 84720. Present address: U.S. Forest Service, Lloyd 500 Building, Suite 1692, 500 NE Multnomah, Portland, Oregon 97232.

[3] This is one of a series of papers funded by the Navajo and Kaiparowits Generating Stations participants.

The list is based upon the plant collections made by the authors and by others at the Navajo-Kaiparowits Project during the period from 1971 to 1975. Additionally, all plants in the herbarium of Brigham Young University have been reviewed, and the pertinent specimens are cited in the list. Lists published by others have been studied and some species added in that manner, but unless the reports could be validated, questionable reports have been excluded. All specimens cited are in the herbarium of Brigham Young University (BRY) unless otherwise indicated.

The list should not be thought to be exhaustive; other species will be found in the Basin. This is indicated by species being added to the list in the summer of 1975, following several years of extensive investigation of the region to sample its flora.

Many of the plants are recognized as threatened (T), endangered (E), or possibly extinct (PoEx). Designations for these species is in a paper by Welsh et al. (1975). Some 42 species in the Kaiparowits Basin are considered as belonging to one of these categories. This number represents about 5 percent of the species in the Basin and approximately 20 percent of the threatened, endangered, or possibly extinct species known for Utah. The following species, with status indicated, belong to this unique group of plants.

Astragalus desperatus var. *conspectus* (T)
Astragalus bryantii (PoEx)
Astragalus emoryanus (T)°
Astragalus hallii var. *fallax* (T)°
Astragalus kentrophyta var. *coloradoensis* (T)°
Astragalus lancearius (T)
Astragalus malacoides (T)
Astragalus striatiflorus (E)
Atriplex navajoensis (T)
Carex curatorum (T)
Castilleja revealii (E)
Cirsium rydbergii (T)°
Cladium californicum (E)°
Draba subalpina (T)
Erigeron abajoensis (T)
Euphorbia nephradenia (T)
Geranium marginale (T)
Gilia latifolia (T)°
Imperata breviflora (PoEx)°
Ivesia sabulosa (T)°
Lesquerella rubicundula (T)
Lesquerella tumulosa (E)
Lomatium minimum (T)
Machaeranthera glabriuscula var. *confertiflora* (T)
Menodora scabra (T)
Muhlenbergia curtifolia (T)°
Nama retrorsum (T)
Oenothera megalantha (E)°
Oxytropis jonesii (T)°
Penstemon leiophyllus (T)
Phacelia cephalotes (T)
Phacelia constancei (T)
Phacelia mammillariensis (E)
Phacelia rafaelensis (T)
Phlox cluteana (T)°
Pinus longaeva (T)°
Primula specuicola (T)
Psoralea epipsila (E)
Ptelea trifoliata ssp. *pallida* (PoEx)°
Townsendia minima (T)
Viguiera annua (T)
Yucca toftiae (T)

Most of these plants occupy only small portions of the Basin, and they must be avoided by any planned development of the region. Generally, the plants are those which occupy some specific habitat or soil types, and they are not known to be cultivatable by standard agricultural techniques. Thus, the only means of preservation of these unique plants lies in the maintenance of the areas occupied by them.

In the annotated list, the collector's names have been appreviated or shortened. The most commonly noted collectors are as follows; a look at collection dates will allow one to determine an outline of the history of floristic investigations of the Basin.

Abbreviation	*Collector's Name*
Boyle	W. S. Boyle
Burkey	N. Burkey
BW	B. W. Wood
Christensen	E. M. Christensen
Beck	D. E. Beck
Buchanan	H. Buchanan
CAT	C. A. Toft
Cottam	W. P. Cottam
DT	D. Trotter
JRM	J. R. Murdock
Gentry	J. Gentry, Jr.
Harrison	B. F. Harrison
Holmgren	N. Holmgren
Holmgren	P. Holmgren
Karren	J. B. Karren
LCH	L. C. Higgins

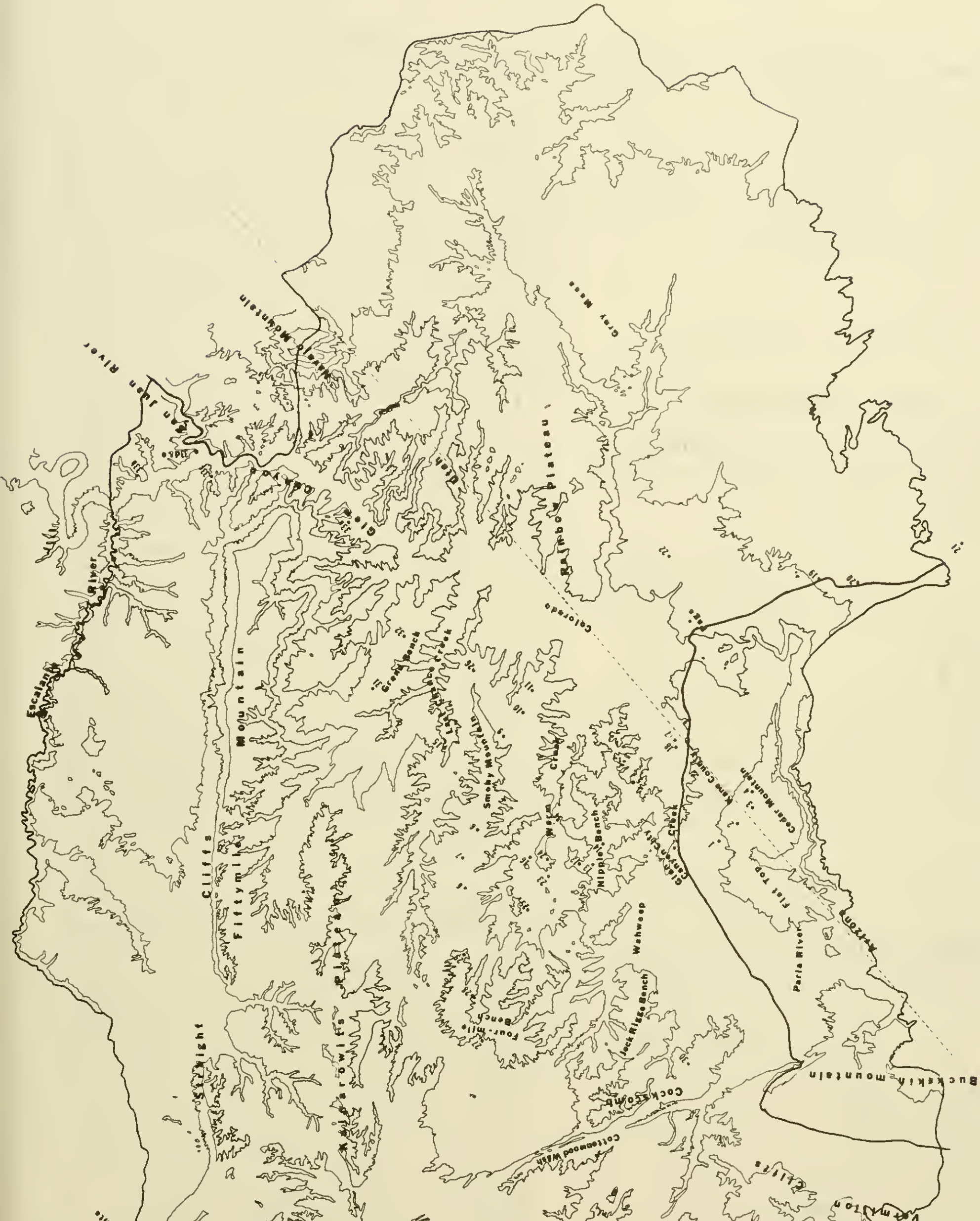

San Juan River
Navajo Mountain
Gray Mesa
Rainbow Plateau
Glen Canyon
Colorado River
Escalante River
Escalante
Fiftymile Mountain
Cliffs
Straight Cliffs
Kaiparowits Plateau
Grand Bench
Last Chance Creek
Smoky Mountain
Warm Creek
Nipple Bench
Wahweap
Four-mile Bench
Cockscomb
Cottonwood Wash
Vermilion Cliffs
Buckskin Mountain
Paria River
Flat Top
Cedar Mountain
Kane County

Fig. 1. The Kaiparowits Basin of Utah and Arizona

NDA	N. D. Atwood
Nebeker & Skougard	G. Nebeker & M. Skougard
RA or RWA	R. W. Allen
Reveal	J. L. Reveal
SLW	S. L. Welsh
SL & SLW	S. L. & S. L. Welsh
Stanton	W. D. Stanton
Tanner	V. M. Tanner
Webb	M. Webb
Woodruff	D. W. Woodruff

ANNOTATED CHECKLIST

ACERACEAE (Maple Family)

Acer glabrum **Torr.** Rocky Mountain Maple

Utah: Garfield Co., Bryce Canyon, Boyle 1154. Rare.

Acer grandidentatum **Nutt.** Big-Tooth Maple

Utah: Garfield Co., Bryce Canyon, Buchanan 379. Kane Co., Kaiparowits Plateau, JRM 399. Rare.

Acer negundo **L.** Box Elder

Arizona: Coconino Co., Paria Canyon, NDA & LCH 4015, 20 May 1972. **Utah:** Kane Co., Escalante Canyon, NDA & RA 3216. Uncommon to locally common along streams and in some hanging gardens.

AIZOACEAE (Carpetweed Family)

Mollugo cerviana **(L.) Ser.**

Utah: Kane Co., Cedar Mt., NDA 3101. Rare.

AMARANTHACEAE (Amaranth Family)

Acanthochiton wrightii **Torr.**

Arizona: Coconino Co., 9.3 miles south of Page, NDA et al. 3346, 3346a. **Utah:** Kane Co., 2 miles west of Glen Canyon City, NDA & DK 3360, 3360a. The Utah collections are the first known record of this rare plant for Utah.

Amaranthus graecizans **L.**

Utah: Kane Co., Cockscomb, NDA & RA 2888b. San Juan Co., Colorado River, across from Last Chance Creek, Gaines (1960).

Tidestromia lanuginosa **(Nutt.) Standl.**

Utah: Kane Co., 30 miles east of Glen Canyon City NDA & DK 3335; 18 miles east of Glen Canyon City, NDA 4059. Uncommon.

ANACARDIACEAE (Cashew Family)

Rhus trilobata **Nutt. var. *trilobata*** Skunkbush

Utah: Garfield Co., Escalante Canyon, Beck s. n.; Escalante, Beck & Tanner s. n. Kane Co., 50 miles south of Escalante, Beck & Tanner s.n.; Nipple Spring, NDA & RA 2825. Rocky slopes and canyons, usually near moist seeps or along drainages; uncommon.

Rhus trilobata **Nutt. var. *simplicifolia*** **(Greene) Barkley**

Arizona: Coconino Co., Lee's Ferry, Cottam 2607. **Utah:** Kane Co., Willow Tank, Beck & Tanner s. n.; 8 miles south of Paria Townsite, Harrison 12046; Four Mile Bench, SLW & NDA 12376; Hole-in-the-Rock, Harrison 12128; Cockscomb, SLW 5330; Tibbet Canyon, NDA 3461; Wahweap Creek, NDA 3475. Rocky slopes in canyons; common.

Toxicodendron rydbergii **(Small) Greene** Poison Ivy

Utah: San Juan Co., one mile east of Hole-in-the-Rock, SLW & CAT 11868. Confined to moist sites, especially in hanging gardens, where it is uncommon but locally abundant.

APOCYNACEAE (Dogbane Family)

Amsonia eastwoodiana **Rydb.**

Utah: San Juan Co., east of confluence of San Juan, NDA 4089; Three Garden, SLW & NDA 11699. Sandy sites in warm dry canyons; common.

Amsonia palmeri **Gray**

Arizona: Coconino Co., near Lee's Ferry, NDA 4429. Rare.

Amsonia tomentosa **Torr. & Frem.**

Utah: San Juan Co., east of confluence of the San Juan, NDA 4090; do, NDA 3182. Dry rocky ground; uncommon.

Apocynum androsaemifolium **L.**

Utah: Garfield Co., Bryce Canyon, Cottam 2744. Moist canyons and slopes at higher elevations; uncommon.

Apocynum cannabinum **L.** Dogbane

Utah: Garfield Co., Escalante, Cottam 4396. Kane Co., Coyote Creek, Brigham Plains area, NDA & RA 2802; Little Valley

Canyon, NDA et al. 2718. San Juan Co., Escalante Canyon, NDA 4116. Seeps, springs, and hanging gardens; common.

Asclepiadaceae (Milkweed Family)

***Asclepias asperula* Decne** Rough Milkweed
Utah: Garfield Co., Escalante Canyon, Woodruff 1164. Kane Co., Dry Rock Creek, Lake Powell, SLW & NDA 11628; head of Last Chance Creek. NDA 4072. San Juan Co., Navajo Mt., NDA et al. 2973; do, NDA 4196; Three Garden, SLW & NDA 11679. Widespread but uncommon.

***Asclepias cryptoceras* Wats.** Hidden-horn Milkweed
Utah: Garfield Co., 1.3 miles south of Cannonville, Reveal et al. 762. Kane Co., Cottonwood Wash road, LCH & NDA 5258; do, NDA & RA 2907. Clay soils, widespread but uncommon.

***Asclepias labriformis* Jones**
Utah: Garfield Co., 10 miles southeast of Escalante, Holmgren et al. 2042. Utah endemic; widespread northward.

***Asclepias latifolia* (Torr.) Raf.**
Utah: Kane Co., 50 miles south of Escalante, Beck & Tanner s. n.; Cedar Mt., NDA 2919; Flat Top, NDA et al. 2959; Escalante Canyon, SLW & GM 11812; 31.5 miles east of Glen Canyon City, NDA et al. 2700. Sandy sites, especially among boulders on talus; uncommon.

***Asclepias macrosperma* Eastw.**
Arizona: Coconino Co., Navajo Canyon, NDA 3728. **Utah:** Kane Co., Cockscomb, SLW 5350; 5 miles north of Glen Canyon Dam, LCH 1006; 13 miles west of Glen Canyon City, NDA & RA 2859; Escalante Canyon, NDA 4215; 2 miles east of Glen Canyon City, NDA 2918; Hole-in-the-Rock, White 212, do, Harrison 12146; Wahweap Creek, Harrison 12089; Paria River, SLW & NDA 9752. Sandy soils at low elevations; common.

***Asclepias subverticillata* (Gray) Vail**
Utah: Garfield Co., east of Escalante, Holmgren & Holmgren 4723. Kane Co., 30 miles east of Kanab, NDA 5588.

***Asclepias tuberosa* L. var. *interior* Woodson**
Utah: Garfield Co., east of Escalante, Holmgren et al. 2117; Escalante, Cottam 4381, Escalante Canyon, Beck s.n. Rare in sandy rimrock situations.

***Funastrum heterophyllum* (Engelm.) Standl.** Climbing Milkweed
Arizona: Coconino Co., Lee's Ferry, Cottam 2617; do NDA 6388. **Utah:** Kane Co., Hole-in-the-Rock, Harrison 12730. San Juan Co., Three Garden, NDA 4263. Talus slopes, canyon of the Colorado; rare.

Berberidaceae (Barberry Family)

***Mahonia fremontii* Torr.** Fremont Mahonia
Utah: Kane Co., 35 miles southeast of Escalante, Harrison 12341; Nipple Canyon, RA 257; Tibbet Spring, NDA 3463; 20 miles south of Cannonville, Christensen s.n.; 8 miles south of Paria Townsite, Harrison 12060. Common in drainages and benchlands through much of the Basin.

***Mahonia repens* L.** Creeping Oregon-grape
Utah: Garfield Co., Bryce Canyon, Burkey 124. Kane Co., Brigham Plains vicinity, NDA & RA 2798; Buckskin Mountain, NDA 4658; Kaiparowits Plateau, JRN 398. San Juan Co., Navajo Mt., NDA 4159. Mountains and moist drainages; locally common.

Betulaceae (Birch Family)

***Betula occidentalis* Hook.** River Birch
Utah: Garfield Co., Bryce Canyon, Boyle 1155. Kane Co., Escalante Canyon, SLW & GM 11829; head of Wahweap Creek, SLW & BW 12441. Along drainages and seeps and springs; uncommon.

***Ostrya knowltonii* Cov.** Knowlton Ironwood
Utah: San Juan Co., Rincon Canyon, NDA 4103; do, SLW & GM 11783; do SLW & NDA 11693; do, SLW & NDA 11711; do SLW 11893. Local in Ribbon Canyon, and observed in Escalante Canyon; rare.

Boraginaceae (Borage Family)

***Coldenia hispidissima* (Torr.) Gray**
Arizona: Coconino Co., upstream from Lee's Ferry, NDA & LCH 4032. **Utah:** Kane Co., Cedar Mt., NDA 3096; Gunsight Bay, SLW & NDA 11576; Wahweap Creek,

Lake Powell, NDA 3702. Sandy sites at low elevations; common.

Cryptantha abata **Johnst.**

Utah: Garfield Co., Bryce Canyon, Boyle 1117. Kane Co., Last Chance Creek, NDA 3747; Collet Wash, NDA 1866. Clay soils; local and uncommon.

Cryptantha bakeri **Pays.**

Utah: Garfield Co., Bryce Canyon, Weight s. n., 1934; 4 miles southwest of Cannonville, Reveal et al. 772; Canaan Peak, NDA & DT 5314. Moderate to high elevations; uncommon.

Cryptantha capitata **(Eastw.) Johnst.**

Utah: Kane Co., Kaiparowits Plateau, NDA & DT 5253. High elevations; rare.

Cryptantha circumscissa **(H. & A.) Johnst.**

Arizona: Coconino Co., one mile west of Glen Canyon Dam, NDA 3447. **Utah:** Kane Co., East Clark Bench, LCH 4251, 20 May 1971; Paria River, SLW & NDA 9747; Warm Creek, NDA 3712; Grand Bench, NDA 3526; Kaiparowits Plateau, Holmgren et al. 2068; Labyrinth Canyon, Lake Powell, NDA 3737; Cottonwood Wash road, Reveal & Gentry 809; Cedar Mt., NDA 2736a. Sandy soils, a common spring annual.

Cryptantha confertiflora **(Greene) Pays.**

Utah: Garfield Co., 8 miles southeast of Escalante, Holmgren et al. 2036. Kane Co., Paria Townsite, Webb 62; Collet Wash, NDA 1873; Paria River, NDA & LCH 3957; Hackberry Canyon, NDA 3678; Ahlstrom Point road, NDA 3668; Cockscomb, NDA 3613; Tibbett Canyon, NDA 3602. Common yellow-flowered perennial of sandy soils.

Cryptantha crassisepala **(T. & G.) Greene**

Arizona: Coconino Co., 3 miles south of Wahweap Marina, SLW & NDA 9768; upstream from Lee's Ferry, NDA 4593: Paria Plateau, NDA & LCH 3767. **Utah:** Garfield Co., Willow Tank, Beck & Tanner s. n.; Warm Creek, NDA 3715; Paria River, NDA & LCH 3976; Wahweap Bay, Lake Powell, NDA 3551; Paria River, SLW & NDA 9748. Annual plant of sandy soils; common.

Cryptantha fendleri **(Gray) Greene**

Arizona: Coconino Co., Lee's Ferry, NDA 4573; one mile west of Glen Canyon Dam. NDA 3569. **Utah:** Kane Co., 2 miles west of Glen Canyon City, Nebeker & Skougard 191; Paria River, NDA & LCH 3944; Little Valley Canyon, NDA 3520. Sandy soils; uncommon.

Cryptantha flava **(A. Nels.) Pays.**

Arizona: Coconino Co., east of Glen Canyon Dam, NDA 3451. do, SLW & NDA 9778; 9 miles south of Page, RA 218. **Utah:** Garfield Co., Escalante, Cottam 4408. Kane Co., 31 miles south of Escalante, Karren 89; Cottonwood Wash road, NDA & RA 2807; East Clark Bench, NDA & RA 2677; Kaiparowits Plateau, Woodruff 1147; Paria River, SLW & NDA 9750; Grand Bench, NDA 3528; head of Rock Creek, Harrison 9033; Cockscomb, SLW 5342; Buckskin Gulch, SLW 5319. Widespread and common, yellow-flowered, ubiquitous plant.

Cryptantha fulvocanescens **(Gray) Pays. var.** *echinoides* **(Jones) Higgins**

Utah: Garfield Co., 1.3 miles south of Cannonville, Reveal et al. 745. Kane Co., Cottonwood Wash road, NDA 3468; 5 miles east of Butler Valley, NDA 3458a; 6 miles southeast of Canaan Peak, SLW & NDA 12372; head of Last Chance Creek, NDA 3752; Paria Townsite, SLW & NDA 9729; East Clark Bench, NDA & RA 2673. Sandy to clay soils; common.

Cryptantha gracilis **Osterch.**

Utah: Kane Co., Four Mile Bench, SLW & JRM 12409; Kaiparowits Plateau, NDA & DT 5288; Cockscomb, NDA 4608; Kaiparowits Plateau, Harrison 9070a. Understory in pinyon-juniper woodland; common.

Cryptantha humilis **Gray Pays. var.** *commixta* **(Macbr.) Higgins**

Utah: Garfield Co., Bryce Canyon, Buchanan 1484 (Bryce). Kane Co., Ahlstrom Point road, NDA 3669; Five Mile Mountain, NDA 4642. Rocky soils at middle elevations; uncommon.

Cryptantha jamesii **(Torr.) Pays. var.** *disticha* **(Eastw.) Pays.**

Arizona: Coconino Co., Page vicinity, SLW & NDA 9777, do, NDA 3452. **Utah:** Kane Co., Paria River, NDA & LCH 3970; 24 miles west of head of Collet Wash, NDA 1873a; Nipple Bench, NDA & RA 2816; Tibbet Canyon, NDA 3601; Crosby Canyon, NDA 3634; Kaiparowits Plateau, NDA & DT 5239; Cockscomb, NDA 3581; Hackberry Canyon, NDA 3677. Ubiquitous; common.

Cryptantha jamesii **(Torr.) Pays. var.** ***pustulosa*** **(Rydb.) Harrington**

Utah: Kane Co., Circle Cliffs, Beck s. n.

Cryptantha jamesii **(Torr.) Pays. var.** ***setosa*** **(Jones) Johnst.**

Utah: Kane Co., Cottonwood Wash road, LCH & NDA 5261; 20 miles east of Kanab, NDA 1792a. Uncommon.

Cryptantha micrantha **(Torr.) Johnst.**

Arizona: Coconino Co., Lee's Ferry, NDA 4577; 3 miles south of Wahweap Marina, SLW & NDA 9767. **Utah:** Kane Co., Cedar Mt., NDA et al. 2735; Warm Creek, NDA 3708; Paria River, NDA & LCH 3950; 2 miles west of Glen Canyon City, Nebeker & Skougard 185. Sandy soil; common.

Cryptantha nevadensis **Nels. & Kenn.**

Arizona: Coconino Co., upstream from Lee's Ferry, NDA 4587; Lee's Ferry, NDA 4571. **Utah:** Kane Co., Labyrinth Canyon, Lake Powell, NDA 3736; 6 miles east of Glen Canyon City, SLW & NDA 9810. Lower elevations; uncommon.

Cryptantha pterocarya (Torr.) Greene

Arizona: Coconino Co., Lee's Ferry, NDA 4572; upstream from Lee's Ferry, NDA 4586; one mile west of Glen Canyon Dam, NDA 3568. **Utah:** Kane Co., Hackberry Canyon, NDA 3676; Kaiparowits Plateau, Holmgren et al. 2064; one mile west of Glen Canyon City, Cronquist 10155; Cedar Mt., NDA et al. 2736, 1971. Sandy soils; common.

Cryptantha recurvata **Cov.**

Arizona: Coconino Co., Lee's Ferry, NDA 4570. **Utah:** Kane Co., Little Valley Canyon, NDA 3518; Nipple Canyon, RA 247; Labyrinth Canyon, Lake Powell, NDA 3738; Kaiparowits Plateau, Harrison 9070 b; 6 miles east of Glen Canyon City, SLW & NDA 9811. San Juan Co., Three Garden, SLW & NDA 11703. Sandy soils; uncommon.

Cryptantha setosissima **(Gray) Pays.**

Utah: Garfield Co., Bryce Canyon, Buchanan 2053 (Bryce).

Heliotropium convolvulaceum **(Nutt.) Gray** Heliotrope

Utah: Kane Co., Cedar Mt., NDA & RA 3073; Warm Creek, NDA & RA 2846. Dunes, sandy terraces, and drainages; uncommon.

Lappula occidentalis **(Wats.) Greene**

Arizona: Coconino Co., upstream from Lee's Ferry, NDA 4584. **Utah:** Garfield Co., Bryce Canyon, Weight s. n.; 1.3 miles south of Cannonville, Reveal et al. 752. Kane Co.; Willow Tank, Beck & Tanner s. n.; Cockscomb, NDA 3626, Cottonwood Wash road, NDA & RA 2756; Gunsight Bay Lake Powell, SLW & NDA 11586; Paria River, NDA & LCH 3981. Kaiparowits Plateau, NDA & DT 5286; Four Mile Bench, NDA 3756. Ubiquitous; common.

Lithospermum incisum **Lehm.**

Utah: Garfield Co., Bryce Canyon, Buchanan 1449, 1454, and 1483 (Bryce); do, Boyle 1112. Kane Co., Grosvenor Arch vicinity, NDA 3469; Cottonwood Wash road, Reveal 814; Horse Mt., Four Mile Bench vicinity, SLW & NDA 12371. Uncommon, widespread.

Lithospermum multiflorum **Torr.** Stoneseed

Utah: Garfield Co., Bryce Canyon, Buchanan 1448 (Bryce): do, Boyle 1114.

Pectocarya platycarpa **Munz**

Utah: San Juan Co, Three Garden, SLW & NDA 11906. Sandy soils; uncommon to rare.

CACTACEAE (Cactus Family)

Coryphantha vivipara **(Nutt.) Britt. & Rose var.** ***arizonica*** **(Engelm.) W. T. Marshall**

Utah: San Juan Co., Navajo Mt., NDA 4151. Widespread; rare.

Echinocereus engelmannii **(Parry) Rumpler** Hedgehog Cactus

Utah: Kane Co., Brigham Plains, NDA & RA 2784a; 36 miles east of Glen Canyon City, NDA et al. 2707. Dry, open slopes, at lower elevations; uncommon.

Echinocereus triglochidiatus **Engelm. var.** ***melanacanthus*** **(Engelm.) Benson**

Utah: Garfield Co., 1.5 miles south of Cannonville, Reveal et al. 768. Kane Co., Four Mile Bench, SLW & JRM 12397a; 8 miles south of Glen Canyon City, NDA 3556; Cockscomb, SLW 5364; Willow Tank, SLW s.n. 18 miles south of Paria Townsite, Harrison 12056. Widespread, mostly at middle elevations; uncommon.

Opuntia basillaris **Engelm. & Bigel var. *aurea* (Baxter) Benson**

Utah: Kane Co., Four Mile Bench, SLW & JRM 12397. Widespread and locally common, middle elevations.

Opuntia chlorotica **Engelm. & Bigel.**

Arizona: Coconino Co., Lee's Ferry, Clover and Jotter (1941).

Opuntia erinacea **Engelm. & Bigel. var. *histricina* (Engelm. & Bigel.) Benson**

Utah: Kane Co., Grand Bench, NDA 4258; Little Valley Canyon, NDA et al. 2732. Common low elevations.

Opuntia erinacea **Engelm. & Bigel. var. *utahensis* (Engelm.) Benson**

Utah: Kane Co., Four Mile Bench, NDA 4057. Widespread; locally common.

Opuntia macrorhiza **Engelm. var. *macrorhiza***

Utah: San Juan Co., Surprise Valley, Clover and Jotter (1941).

Opuntia phaecantha **Engelm.**

Utah: San Juan Co., Navajo Mt., NDA 4141. Common in low elevation canyons and terraces.

Opuntia polyacantha **Haw. var. *polyacantha***

Utah: Kane Co., 20 miles east of Glen Canyon City, NDA 4063; Fifty Mile Spring, White 155. Widespread and locally common.

Opuntia whipplei **Engelm. & Bigel.**

Arizona: Coconino Co., 9.3 miles south of Page, NDA 4083; Kaibito-Tonolea road, NDA et al. 2912. **Utah:** Kane Co., Cedar Mt., SLW & JRM s.n. Sandy sites at low to moderate elevations in southern portion of basin; uncommon.

Sclerocactus whipplei **(Engelm. & Bigel.) Britt. & Rose**

Utah: Kane Co., Four Mile Bench, SLW & JRM 12411; Crosby Canyon, NDA 3636; 8 miles south of Glen Canyon City, NDA 3557. Widespread; uncommon to locally common.

CAMPANULACEAE (Bellflower Family)

Campanula parryi **Gray**

Utah: Garfield Co., Bryce Canyon, Weight s. n., 1934; Escalante Canyon, Beck 134. Moist sites; uncommon.

Campanula rotundifolia **L.**

Utah: Garfield Co., Bryce Canyon, Buchanan 1723 (Bryce). Uncommon.

Lobelia cardinalis **L. ssp. *graminea* (Lam.) McVaugh**

Utah: Kane Co., Reflection Canyon, Lake Powell, SLW 11879; Escalante Canyon, NDA & RA 3204. San Juan Co., Rainbow Bridge, NDA & RA 3301; Three Gardens, NDA & RA 3192; do, NDA et al. 3228; east of confluence of the San Juan, NDA & RA s.n. Hanging gardens and seeps; uncommon except locally.

Nemacladus glanduliferus **Jeps. var. *orientalis* McVaugh**

Arizona: Coconino Co., Lee's Ferry, NDA 4576. Uncommon; southern portion of included area.

CAPPARIDACEAE (Caper Family)

Cleome lutea **Hook.** Beeplant

Utah: Garfield Co., Escalante, Beck & Tanner s.n.; 5 miles west of Escalante, Anderson 683; 1.3 miles south of Cannonville, Reveal et al. 751; Kane Co., 50 miles south of Escalante, Beck & Tanner s.n., 16 June 1936; Escalante Canyon, SLW & GM 11831; Paria River, SLW & NDA 9742; East Clark Bench, LCH 4246; Left-hand fork of Collet Wash, Woodruff 1160; Cottonwood Wash road, NDA & RA 1769; Cockscomb, SLW 5351. Widespread; common.

Cleome serrulata **Pursh**

Utah: Kane Co., Paria River, NDA & LCH s.n.; Four Mile Bench, NDA 4303. Widespread; uncommon.

Cleomella palmeriana **Jones**

Utah: Garfield Co., one mile east of Henrieville, NDA 1877; 18 miles west of Escalante, SLW 9411. Kane Co., Crosby Canyon, NDA 3635; 17 miles northeast of Glen Canyon City, RA 203; Paria River, NDA & LCH 3989; Cottonwood Wash road, NDA & LCH 3830; 18 miles east of Glen Canyon City, NDA 4058; 4 miles east of Glen Canyon City, NDA 2629. Restricted to clay soils, mainly on the Tropic Shale formation; endemic to the Navajo Basin of Utah and Colorado; common.

CAPRIFOLIACEAE (Honeysuckle Family)

Sambucus coerulea **Raf.** Elderberry
Utah: Garfield Co., between Death Ridge and Canaan Peak, SLW et al. 12589. San Juan Co., Navajo Mt., NDA et al. 2979. Canyons and slopes at middle elevations; uncommon.

Symphoricarpos longiflorus **Gray** Snowberry
Utah: Kane Co., Brigham Plains vicinity, NDA & RA 2799. San Juan Co., Ribbon Garden, Lake Powell, SLW & NDA 11696. Common in canyons at low to moderate elevations.

Symphoricarpos parishii **Rydb.**
Utah: San Juan Co., Navajo Mt., NDA 4146. Uncommon.

Symphoricarpos vaccinioides **Rydb.**
Utah: Garfield Co., vicinity of Death Ridge SLW & JRM s.n., June 1975. Kane Co., Bryce Canyon, Boyle 1132; Kaiparowits Plateau, NDA & DT 5290. Middle and higher elevations; uncommon.

CARYOPHYLLACEAE (Pink Family)

Arenaria eastwoodiae **Rydb.** Sandwort
Utah: Kane Co., Hole-in-the-Rock, Harrison 12144; 16 miles east of Glen Canyon City, NDA 3667; Kaiparowits Plateau, NDA & DT 52227. Sandy sites and rimrock; uncommon.

Arenaria fendleri **(Rydb.) Fern.**
Utah: Garfield Co., Canaan Peak, NDA & DT 5318. Uncommon.

Arenaria kingii **Wats.**
Utah: Garfield Co., 2 miles southeast of Escalante, NDA S.N. Kane Co., Four-Mile Bench, NDA 4304.

Arenaria nutallii **Wats.**
Utah: Garfield Co., Bryce Canyon, Burkey 129. Uncommon; higher elevations.

Silene antirrhina **L.**
Arizona: Coconino Co., 9.3 miles north of junction of US 89 and 169, NDA 3656. **Utah:** Kane Co., Cockscomb, NDA 4609. San Juan Co., Three Garden, SLW & NDA 11667, 4 May 1972; Ribbon Canyon, SLW & NDA 11712; Trail Canyon, Lake Powell, SLW 11911. Widespread; uncommon.

Silene scouleri **Hook. ssp.** ***pringlei*** **(Wats.) Hitchc. & Maguire**
Utah: San Juan Co., Navajo Mt., NDA 4180. Rare.

Stellaria jamesiana **Torr.** James Starwort
Utah: Kane Co., Kaiparowits Plateau, NDA & DT 5239. San Juan Co., Navajo Mt., NDA et al. 2994; do, Gentry & Davidse 1770. Uncommon; middle elevations.

CELASTRACEAE (Bittersweet Family)

Forsellesia spinescens **(Gray) Greene** Greasebush
Utah: Kane Co., Cockscomb, NDA 4613. Uncommon.

Pachystima myrsinites **(Pursh) Raf.** Mountain Lover
Utah: Garfield Co., Bryce Canyon, Buchanan 1488 (Bryce). Uncommon.

CHENOPODIACEAE (Goosefoot Family)

Atriplex canescens **(Pursh) Gray** Fourwing Saltbush
Utah: Garfield Co., Escalante Canyon, Harrison 9142. Kane Co., Four Mile Bench, SLW et al. 12583; Nipple Bench, NDA & RA 2821; Gunsight Bay, SLW & NDA 11592; Hole-in-the-Rock, Hansen 432a; 13 miles east of Warm Creek Junction, NDA 3457. Common throughout the Basin in most vegetative types.

Atriplex confertifolia **(Torr. & Frem.) Wats.** Shadscale
Utah: Garfield Co., 3 miles east of Henrieville, Hansen 395. Kane Co., Nipple Canyon, RA 248; Gunsight Bay, Lake Powell, SLW & NDA 11588; 5 miles southeast of Cannonville, Reveal et al. 794; Sit Down Bench, Patton 137; 6 miles east of Glen Canyon City, SLW & NDA 9803. Throughout the Basin; abundant.

Atriplex corrugata **Wats.** Mat-Atriplex
Utah: Kane Co., lower Wahweap Creek, Albee 60; 30 miles east of Glen Canyon City, NDA 4545; Ahlstrom road, RA 120; Nipple Canyon, RA 261; Cottonwood Wash road, Reveal et al. 826; 6 miles east of Glen Canyon City, SLW & NDA 9802. Principal perennial vegetation of Tropic Shale formation.

Atriplex garrettii **Rydb.**
Utah: Kane Co., Hole-in-the-Rock, Hansen 432b; San Juan Co., Three Garden, SLW & NDA 11687; east of confluence of

the San Juan, NDA 4088; Ribbon Garden, NDA 4109; between Three Garden and Willow Cove, Lake Powell, SLW 11895. Talus slopes, canyons of the Colorado; uncommon.

***Atriplex graciliflora* Jones**

Utah: Kane Co., Warm Creek, NDA & RA 2839; 29.2 miles southeast of Escalante, Reveal et al. 827. Saline soils; uncommon.

***Atriplex jonesii* Standl.**

Arizona: Coconino Co., Lee's Ferry, Clover and Jotter (1941).

***Atriplex navajoensis* Hanson** Navajo Saltbush

Arizona: Coconino Co., Lee's Ferry, NDA 6393; do, Cottam 2620; do, NDA 4351, 4352. Endemic to Coconino County, Arizona; known only from Lee's Ferry to Navajo Bridge vicinity; possibly threatened.

***Atriplex powellii* Wats.**

Utah: Garfield Co., 2 miles east of Henrieville, NDA 5359. Kane Co., Cottonwood Wash road, Reveal et al. 828. Locally and periodically abundant, especially on saline clay soils.

***Atriplex saccaria* Wats.**

Utah: Kane Co., Cockscomb, NDA & RA 2883; Little Valley Canyon, SLW & NDA 11610. Uncommon, saline clay soils.

***Ceratoides lanata* (Pursh) Howell** Winterfat

Utah: Kane Co., Last Chance Bay, Lake Powell, NDA et al. 3291; one mile east of Church Wells, NDA & RA 3116; 5 miles south of Glen Canyon City, NDA & RA 3116. Common in low elevations, especially on sandy or silty soils.

***Chenopodium fremontii* Wats.** Goosefoot

Utah: Kane Co., Dry Rock Creek, SLW & NDA 11623; miles south of Glen Canyon City, NDA 3117a. Uncommon.

***Chenopodium leptophyllum* Nutt.**

Arizona: Coconino Co., 9.3 miles south of Page, NDA et al. 3340. **Utah:** Kane Co., near mouth of Kane Creek Gaines (1960). Uncommon to rare.

***Chenopodium pratericola* Rydb.**

Utah: Kane Co., 5 miles south of Glen Canyon City, NDA 3117. Rare to uncommon.

***Chenopodium* sp.**

Utah: Kane Co., Reflection Canyon, SLW 11876.

***Corispermum hyssopifolium* (Pallas) L.** Bugseed

Arizona: Coconino Co., 9.3 miles south of Page, NDA et al. 3343. **Utah:** Kane Co., Four Mile Bench, NDA 4309. Uncommon.

***Corispermum nitidum* Kit.**

Arizona: Coconino Co., Teetso Spring, NDA 3420; 25 miles north of Shonto, NDA & DT 3392. **Utah:** San Juan Co., 5.5 miles below Klondike Bar, Gaines (1960). Uncommon.

***Cycloloma atriplicifolium* (Spreng.) Coult.**

Utah: Kane Co., Willow Tank, Beck & Tanner s.n.; Warm Creek, NDA et al. 3289.

***Grayia brandegei* Gray**

Utah: Garfield Co., 12 miles east of Henrieville, Hanson 396a; 18 miles west of Escalante, SLW 9140. Kane Co., Hackberry Canyon, NDA 3685; Cottonwood Wash road, Christensen s.n.; do, NDA & DK 3319. Restricted to clay and silty, saline soils where locally abundant.

***Grayia spinosa* (Hook.) Moq.**

Utah: Kane Co., 31 miles east of Glen Canyon City, NDA et al. 2697; Last Chance Bay, Lake Powell, SLW & NDA 11608; Nipple Canyon, RWA 256. Codominant with *Coleogyne ramosissima* in portions of the desert shrub community; uncommon to very common.

***Halogeton glomeratus* (Bieb.) C.A. Meyer**

Utah: Garfield Co., Pet Hollow, NDA 4323. Observed elsewhere; uncommon in the Basin.

***Kochia americana* Wats.** Gray Molly

Utah: Kane Co., observed but not collected. Locally common on pediment gravels overlying Tropic Shale formation east from Glen Canyon City.

***Monolepis nuttalliana* (Schult.) Greene**

Arizona: Coconino Co., upstream from Lee's Ferry, NDA 4583. **Utah:** Kane Co., Warm Creek, NDA 3600; Tibbet Canyon, NDA 3608. Widespread; uncommon.

***Salsola iberica* Sennen & Pau** Russian Thistle

Arizona: Coconino Co., 9.3 miles south of Page, NDA et al. 3348. **Utah:** Kane Co., Willow Tank, Beck & Tanner s.n.; 6 miles east of Glen Canyon City, NDA & DK 3356; Warm Creek, NDA & RA 2837. Widespread, adventive weed.

Sarcobatus vermiculatus **(Hook.) Torr.** Greasewood
Utah: Garfield Co., Pet Hollow, NDA 4328. Greasewood is a dominant plant species in saline soils along drainages throughout middle and lower elevations.

Suaeda fruticosa **(L.) Forsk.** Seepweed
Utah: Garfield Co., 18 miles west of Escalante, SL & SLW 9412. Locally abundant; saline clay soils.

Suaeda torreyna **Wats.**
Utah: Kane Co., Cottonwood Wash road, NDA & DK 3324. Locally abundant; saline clay soils.

COMMELINACEAE (Spiderwort Family)

Tradescantia occidentalis **(Britt.) Smyth** Spiderwort
Arizona: Coconino Co., Paria Canyon, Woodruff 1122. **Utah:** Garfield Co., Escalante Canyon, Beck s.n. San Juan Co., Forbidding Canyon, SLW & NDA 11661; Aztec Canyon, Gaines (1960).

COMPOSITAE (Composite Family)

Acamptopappus sphaerocephalus **(Harv. & Gray) Gray** Goldenhead
Utah: Kane Co., Warm Creek, NDA 3599; Gunsight Bay, SLW & NDA 11589; Dry Rock Creek, SLW & NDA 11624; Labyrinth Canyon, NDA 3731; 14 miles east of Glen Canyon City, NDA 4062. San Juan Co., confluence of the San Juan, SLW 11933. Sandy and gravelly benches at low elevations; locally common.

Achillea millefolium **L.**
Utah: Garfield Co., Escalante Canyon, Beck 144. Widespread at higher and middle elevations; uncommon.

Agoseris arizonica **Greene** Mountain Dandelion
Utah: San Juan Co., Navajo Mt., NDA & DT 5339. Uncommon.

Agoseris aurantiaca **(Hook.) Greene**
Utah: San Juan Co., Navajo Mt., NDA 4168. Uncommon.

Agoseris glauca **(Pursh) D. Dietr.**
Utah: Garfield Co., Bryce Canyon, Weight s.n., 1934. Kane Co., Kaiparowits Plateau, Harrison 9045; do, NDA & DT 5233. High elevations; uncommon.

Ambrosia acanthicarpa **(Hook.) Cov.**
Arizona: Coconino Co., 9.3 miles south of Page, NDA et al. 3342. **Utah:** Kane Co., Cedar Mt., NDA 3120; Paria River, NDA & DK 3374; 6 miles east of Glen Canyon City, NDA & DK 3358; Four Mile Bench, NDA 4306. Sandy and silty soils; widespread and common.

Antennaria dimorpha **(Nutt.) T. & G.** Pussytoes
Utah: Garfield Co., Bryce Canyon, Buchanan 2058 (Bryce). Uncommon.

Antennaria parvifolia **Nutt.**
Utah: Garfield Co., Bryce Canyon, Cottam 2750. San Juan Co., Navajo Mt., NDA 4183. High and moderate elevations; uncommon.

Antennaria rosulata **Rydb.**
Utah: Garfield Co., Bryce Canyon, Buchanan 1718 (Bryce).

Arnica cordifolia **Hook.**
Utah: Garfield Co., Circle Cliffs, Beck s.n.

Artemisia bigelovii **Gray** Bigelow Sagebrush
Utah: Garfield Co., west of Escalante, Cottam 6356. Kane Co., Tibbet Canyon, NDA & DK 3326. Rocky slopes and draws; common.

Artemisia campestris **L.**
Utah: Garfield Co., Escalante Canyon, Beck 116. Uncommon.

Artemisia filifolia **Torr.** Old Man Sagebrush
Utah: Garfield Co., Escalante Canyon Beck 115. Kane Co., 50 miles south of Escalante, Beck & Tanner s.n.; 5 miles south of Glen Canyon City, NDA 3118; Paria River, JRM 322; Nipple Bench, NDA & DK 3328. Common on sandy sites, especially at lower elevations.

Artemisia frigida **Willd.**
Utah: Garfield Co., Bryce Canyon, Buchanan 493; Escalante Canyon, Beck 114. Uncommon.

Artemisia ludoviciana **Nutt.**
Utah: Kane Co., Paria River, NDA & DK 3377; Escalante River, NDA 4221. Locally common especially in talus.

Artemisia nova **A. Nels.** Black Sagebrush
Utah: Garfield Co., Bryce Canyon, Buchanan 73. Abundant at high elevations, mostly west of our area.

Artemisia pygmaea **Gray**
Utah: Garfield Co., locally common to abundant, limestone scablands, Bryce Canyon vicinity; 5 miles west of Widtsoe Junction, SLW & JRM 12563.

Artemisia spinescens **DC.** Bud Sagebrush
Utah: Kane Co., one mile northwest of Warm Creek-Last Chance Road, NDA 3438, Ahlstrom road, RA 121; Nipple Canyon, RA 255. San Juan Co., Rock Creek vicinity, Gaines 91960). Locally common; gravelly pediment over saline soils.

Artemisia tridentata **Nutt.** Big Sagebrush
Utah: Garfield Co., Escalante, Beck & Tanner s.n. Kane Co., Four Mile Bench, SLW 12367. San Juan Co., Navajo Mt., NDA & DK 3396. Common to abundant in openings in juniper-pinyon woodlands at middle elevations.

Aster chilensis **Nees ssp.** ***adscendens*** **(Lindl.) Cronq.** Aster
Utah: Garfield Co., Bryce Canyon, Weight, s.n. Kane Co., Reflection Canyon, SLW 11888. San Juan Co., Surprise Valley, Clover and Jotter (1941). Moist sites; uncommon.

Aster arenosus **(Heller) Blake**
Arizona: Coconino Co., near Tse' eh' aah, Nebeker & Skougard 208. **Utah:** Garfield Co., Bryce Canyon, Cottam 2769; Escalante Beck & Tanner s.n. Kane Co., Four Mile Bench, SLW & JRM 12401; Willow Tank, Harrison, 9115; East Clark Bench, Harrison 12062; Paria River, NDA & LCH 4011; Grand Bench, NDA 3527; Nipple Bench, NDA & RA 2808. Ubiquitous; common.

Aster commutatus **(T. & G) Gray**
Utah: Kane Co., Four Mile Bench, Wahweap Creek, SLW 12568. Seeps and springs; rare.

Aster frondosus **(Nutt.) T. & G.**
Utah: Kane Co., Four Mile Bench, Wahweap Creek, NDA 4316. Seeps; rare.

Aster glaucodes **Blake**
Utah: Garfield Co., Bryce Canyon, Weight s.n.; Pet Hollow, NDA 4335. Kane Co., Escalante Canyon, NDA 4210. Moist or shaded sites; uncommon.

Aster pauciflorus **Nutt.**
Utah: Garfield Co., Escalante Canyon, Beck 1135. Kane Co., Upper Wahweap Creek, NDA 4342. Moist sites; uncommon.

Aster spinosus **Benth.**
Arizona: Coconino Co., Lee's Ferry, Cottam 2626. Rare.

Baccharis emoryi **Gray**
Arizona: Coconino Co., 9.3 miles south of Page, NDA 4085. **Utah:** Kane Co., Driftwood Canyon, SLW & NDA 11649; Reflection Canyon, SLW 11884; Hole-in-the-Rock, Harrison 12125. Moist sites along major, low elevations drainages; locally commmon.

Baccharis glutinosa **Pers.**
Arizona: Coconino Co., Lee's Ferry, Cottam 2619. **Utah:** San Juan Co., 5.5 miles below Klondike Bar, Gaines (1960). Uncommon.

Bahia neomexicana **Gray**
Arizona: Coconino Co., Cockscomb, NDA & DK 3382. Rare.

Balsamorrhiza sagittata **(Pursh) Nutt.**
Utah: Garfield Co., Bryce Canyon, Weight s.n. Kane Co., Horse Mt., north of Four Mile Bench, SLW s.n. Gravelly soils at middle elevations; locally common.

Brickellia atractyloides **Gray**
Utah: San Juan Co., Three Garden, SLW & NDA 11688. Uncommon to rare.

Brickellia californica **(T. & G.) Gray**
Utah: Kane Co., Brigham Plains vicinity, NDA & RA 2794. Rare.

Brickellia longifolia **Wats.**
Utah: Kane Co., Tibbet Canyon, NDA & DK 3332; do, NDA & DK 3411. Canyon bottoms and talus slopes; locally common in tributaries of the Colorado.

Brickellia oblongifolia **Nutt. var.** ***linifolia*** **(DC.) Robinson**
Utah: Garfield Co., Bryce Canyon, Maguire 19105; do Cottam 4363; 3 miles southeast of Escalante, Holmgren et al. 2025. Kane Co., Four Mile Bench. SLW 12832; Willow Tank, Beck & Tanner s.n. Cottonwood Wash road, NDA & RA 2757. Uncommon to locally common at middle and low elevations.

Brickellia scabra **(Gray) A. Nels.**
Arizona: Coconino Co., 8 miles southeast of Page, NDA et al. 3242. **Utah:** Garfield Co., Escalante Canyon, Beck s.n. Locally common on sandstone outcrops.

Calycoseris parryi **Gray**
Utah: Kane Co., Hole-in-the-Rock, Gaines (1960).

Centaurea repens **L.**

Utah: Kane Co., Cottonwood Wash road, NDA & RA 2767; Four Mile Bench NDA 4315. Uncommon; introduced weed.

Chaenactis brachiata **Greene**

Utah: Garfield Co., Bryce Canyon, Cottam 2573. Rare.

Chaenactis douglasii **(Hook.) H. & A.**

Utah: Garfield Co., Bryce Canyon, Weight s.n., 1934. Kane Co., East Clark Bench, JRM 329; Collet Top, Woodruff 1151. San Juan Co., Navajo Mt., NDA et al. 2967. Uncommon to locally common biennial.

Chaenactis macrantha **DC.**

Utah: Kane Co., 20 miles east of Glen Canyon City, NDA & DT 5071; Gunsight Bay, Lake Powell, SLW & NDA 11585. San Juan Co., 2 miles below Last Chance Creek, Gaines, (1960). Locally common in sandy sites at low elevations.

Chaenactis stevioides **H. & A.**

Arizona: Coconino Co., Page vicinity, SLW & NDA 9773. **Utah:** Kane Co., 3.3 miles southwest of Glen Canyon City, NDA et al. 2745; 1.1 miles west of Glen Canyon City, Cronquist 10158; Gunsight Bay, Lake Powell, SLW & NDA 11575; Grand Bench, NDA 3529. Common in sandy sites at low elevations.

Chamaechaenactis scaposa **(Eastw.) Rydb. var.** ***parva*** **Preece & Turner**

Utah: Garfield Co., Red Canyon, Reveal & Reveal 1029. Perhaps outside the limits of the Kaiparowits Basin.

Chrysothamnus depressus **Nutt.**

Utah: Garfield Co., Bryce Canyon, Harrison 11030. Common at moderate elevations.

Chrysothamnus linifolius **Greene**

Utah: Garfield Co., Escalante Canyon, Beck 136. Kane Co., Reflection Canyon, CAT 192; Four Mile Bench, SLW et al. 12574; Last Chance Creek, NDA 427a. A tall shrub of drainage margins; locally abundant.

Chrysothamnus nauseosus **(Pall.) Britt. var.** ***albicaulis*** **(Nutt.) Rydb.**

Utah: Garfield Co., Bryce Canyon, Buchanan 1725 (Bryce). Moderate to high elevations; common.

Chrysothamnus nauseosus **(Pall.) Britt. var.** ***bigelovii*** **(Gray) Hall**

Arizona: Coconino Co., Lee's Ferry, Cottam 2603. Uncommon.

Chrysothamnus nauseosus **(Pall.) Britt. var.** ***consimilis*** **(Greene) Hall**

Arizona: Coconino Co., Lee's Ferry, Clover and Jotter (1941). **Utah:** Kane Co., Tibbet Canyon, NDA & DK 3408, 3409; Last Chance Creek, NDA 4274. Locally common on terraces and flood plains.

Chrysothamnus nauseosus **(Pall.) Britt. var.** ***gnaphaloides*** **(Greene) Hall)**

Utah: Kane Co., Tibbet Canyon, NDA & DK 3410. Locally common along canyon bottoms.

Chrysothamnus nauseosus **(Pall.) Britt. var.** ***graveolens*** **(Nutt.) Hall**

Utah: Garfield Co., Bryce Canyon, Cottam & Hutchings 2775. Locally common at middle elevations.

Chrysothamnus nauseosus **(Pall.) Britt. var.** ***junceus*** **(Greene) Hall**

Utah: Kane Co., Nipple Bench, NDA & DK 3330. Uncommon.

Chrysothamnus nauseosus **(Pall.) Britt. var.** ***leiospermus*** **(Gray) Hall**

Utah: Kane Co., Reflection Canyon, SLW 1182; 2 miles west of Glen Canyon City, NDA & DK 3407. Uncommon.

Chrysothamnus parryi **(Gray) Greene var.** ***attenuatus*** **(Jones) Kittel in Tidestr. & Kittel**

Utah: Garfield Co., Escalante vicinity, Holmgren et al. 2535; Bryce Canyon, Buchanan 1728 (Bryce). Moderate elevations; common.

Chrysothamnus viscidiflorus **(Hook.) Nutt. var.** ***puberulus*** **(Eat.) Jeps.**

Utah: Garfield Co., Bryce Canyon, Buchanan 1726 (Bryce). Moderate elevations; common.

Chrysothamnus viscidiflorus **(Hook.) Nutt. var.** ***stenophyllus*** **(Gray) Hall**

Arizona: Coconino Co., 9 miles southeast of Page, NDA et al. 3240. **Utah:** Kane Co., 2 miles south of Glen Canyon City, NDA 3097; Buckskin Gulch, SLW 9423; East Clark Bench, NDA & DK 3366. Common at lower elevations on several soil types.

Chrysothamnus viscidiflorus **(Hook.) Nutt. var.** ***viscidiflorus***

Utah: Garfield Co., Escalante Canyon, Beck 145. Uncommon.

***Cichorium intybus* L.** Chickory
Utah: Kane Co., Four Mile Bench, NDA 4118. Introduced weed; uncommon.

***Cirsium arizonicum* (Gray) Petrak**
Utah: Kane Co., Four Mile Creek, SLW et al. 12576. Canyon bottom; uncommon.

***Cirsium bipinnatum* (Eastw.) Rydb.**
Utah: Kane Co., Escalante Canyon, SLW & GM 11828. Canyon bottoms; rare.

***Cirsium neomexicanum* Gray**
Utah: Kane Co., Driftwood Canyon, SLW & NDA 11648; Dry Rock Creek, Lake Powell, SLW & NDA 11633; Grand Bench, NDA 4261. Sandy sites, especially in canyons at low elevations; common.

***Cirsium nidulum* (Jones) Petrak**
Utah: Kane Co., Escalante Canyon, NDA 4120. Uncommon.

***Cirsium pulchellum* (Greene) W. & S.**
Arizona: Coconino Co., Paria Canyon, Woodruff 1126. **Utah:** Kane Co., 20 miles east of Glen Canyon City, NDA & DT 5070. Left-hand Fork of Collet Canyon, Woodruff 1154; Wahweap Creek, Four Mile Bench, SLW & BW 12441; Brigham Plains vicinity, NDA & RA 2793; Little Valley Canyon, NDA et al. 2714. Common, especially in canyon bottoms.

***Cirsium rothrockii* (Gray) Petrak**
Utah: San Juan Co., Navajo Mt., Gentry & Davidse 1975. Uncommon.

***Cirsium rydbergii* Petrak**
Utah: San Juan Co., east of confluence of the San Juan, NDA & RA 3181. Endemic to the Navajo Basin, restricted mainly to Hanging Gardens; local and possibly threatened (Welsh et al., 1975).

***Cirsium utahense* Petrak**
Utah: Kane Co., Escalante Canyon, NDA 4115. Uncommon.

***Conyza canadensis* (L.) Cronq.** Horseweed
Utah: San Juan Co., Three Garden vicinity, NDA & RA 3182. Rainbow Bridge, Clover and Jotter (1941).

***Crepis intermedia* Gray**
Utah: Garfield Co., Bryce Canyon, Weight B-31/28. Uncommon.

***Crepis occidentalis* Nutt.**
Utah: Kane Co., Kaiparowits Plateau, NDA & DT 5341. Uncommon.

***Crepis runcinata* T. & G. var. *glauca* (Babcock) Stebb.**
Utah: Kane Co., Four Mile Creek, SLW & BW 12443. Seeps and springs margins; rare.

***Dicoria canescens* Gray**
Utah: Kane Co., East Clark Bench, NDA & DK 3371; 6 miles east of Glen Canyon City, NDA & DK 3371. Common in sandy sites.

***Dyssodia thurberi* (Gray) A. Nels.**
Arizona: Coconino Co., Lee's Ferry, NDA 4565. **Utah:** Kane Co., Escalante Canyon, NDA & RA 3215; do, NDA & RA 3200; Dry Rock Creek; SLW & NDA 11626; Tibbet Canyon, NDA 3609; Rainbow Bridge, SLW & NDA 11652; Hole-in-the-Rock, Beck 141. San Juan Co., east of confluence of the San Juan, NDA & RA 3159. Widespread and common.

***Encelia frutescens* Gray**
Utah: Kane Co., Warm Creek, NDA 3722; Dry Rock Creek, SLW & NDA 11616; Gunsight Bay, SLW & NDA 11579 Last Chance Creek, Woodruff 1142. Widespread in canyons at low elevations; uncommon.

***Enceliopsis nudicaulis* (Gray) A. Nels.**
Arizona: Coconino Co., Lee's Ferry vicinity, Cottam 2629. Rare.

***Erigeron abajoensis* Cronq.**
Utah: Garfield Co., Bryce Canyon, Cottam 2754; do NDA 6128. Kane Co., Kaiparowits Plateau, Harrison 9062. A rare and threatened species endemic to Garfield, Kane, and San Juan counties, Utah (Welsh et al., 1975).

Erigeron bellidiastrum* Nutt. var. *bellidiastrum
Utah: Garfield Co., Escalante, Cottam 4394. Kane Co., 45 miles south of Escalante, Beck 8278, July 1937; 22 miles south of Cannonville, Reveal et al. 810; Hole-in-the-Rock, Buss 93; 2 miles west of Glen Canyon City, NDA 3637. Common.

***Erigeron compositus* Pursh**
Utah: Garfield Co., Bryce Canyon, Cottam 2768. Uncommon; higher elevations.

***Erigeron divergens* T. & G.**
Arizona: Coconino Co., upstream from Lee's Ferry, NDA & LCH 4021. **Utah:** San Juan Co., Three Garden vicinity NDA & RA 3184; Navajo Mt., Gentry & Davidse

1972. Locally common, especially in moist canyon bottoms.

Erigeron eatonii **Gray**

Utah: Garfield Co., Bryce Canyon, Buchanan 2049 (Bryce). Kane Co., Kaiparowits Plateau, Harrison 9062. San Juan Co., Navajo Mt., NDA 4156.

Erigeron flagellaris **Gray**

Utah: Garfield Co., Bryce Canyon, Cottam & Hutchings 2770. Uncommon.

Erigeron pumilus **Nutt. ssp.** ***concinnoides*** **Cronq.**

Utah: Garfield Co., 1.3 miles south of Cannonville, Reveal et al. 754. Kane Co., Four Mile Bench, SLW & JRM 124000; Kaiparowits Plateau, NDA & DT 5227; Brigham Plains vicinity, NDA & RA 2795; Fifty Mile Spring, JRM 358. Widespread; uncommon.

Erigeron speciosus **(Lindl.) DC. var.** ***macranthus*** **(Nutt.) Cronq.**

Utah: Garfield Co., Bryce Canyon, Weight s.n., 1934. Uncommon.

Erigeron utahensis **Gray**

Utah: Garfield Co., Escalante Canyon, McKnight & Beck 199; Escalante, Cottam 4392. Kane Co., 20 miles southeast of Cannonville, Holmgren et al. 2052; Brigham Plains, NDA & RA 2783; 2 miles west of Glen Canyon City, Cronquist 10167; 37 miles east of Glen Canyon City, NDA et al. 2708; Kaiparowits Plateau, NDA & DT 5270; Willow Tank, Harrison 9029; Driftwood Canyon, SLW & NDA 11647; Paria River, NDA & LCH 3978; Warm Creek, NDA & RA 2904. Common; especially in rocky canyon slopes.

Erigeron vagus **Pays.**

Utah: Garfield Co., Bryce Canyon, Reveal 1019. Rare.

Gaillardia gracilis **A. Nels.** Blanket Flower

Utah: Garfield Co., Escalante Canyon, Beck s.n. Kane Co., Cockscomb, SLW 5348; Willow Tank, Harrison 9106; 15 miles west of Glen Canyon City, NDA & RA 2682a. Sandy soils; locally abundant.

Gaillardia parryi **Greene**

Utah: Garfield Co., Escalante vicinity, Holmgren et al. 2073; Kane Co., 10 miles southeast of Cannonville, Reveal et al. 804; Buckskin Wash, SLW 9421. Locally common.

Gaillardia pinnatifida **Torr.**

Utah: Garfield Co., Escalante Canyon, McArthur & Beck 200, June 1940. Kane Co., 6 miles west of Escalante, NDA 3575; 15 miles west of Glen Canyon City, NDA & RA 2862; Paria River, LCH & NDA 5370a. Locally common.

Gnaphalium palustre **Nutt.**

Utah: San Juan Co., near mouth of Aztec Creek, Gaines (1960).

Grindelia aphanactis **Rydb.**

Utah: San Juan Co., Three Garden vicinity, NDA & RA 3189; do SLW & CAT 11864. Locally common; canyon bottoms.

Grindelia squarrosa **(Pursh) Dunal**

Utah: Kane Co., Four Mile Bench, NDA 4321. Locally common.

Gutierrezia microcephala **(DC.) Gray**

Arizona: Coconino Co., 8 miles southeast of Page, NDA et al. 3245. **Utah:** Garfield Co., Escalante Canyon, Beck 120. Kane Co., Tibbet Spring, NDA & DK 3414. Common.

Gutierrezia sarothrae **(Pursh) Britt. & Rusby**

Utah: Garfield Co., Escalante Canyon, Beck 137. Pet Hollow, NDA 4326. San Juan Co., Navajo Mt., Gentry & Davidse 1971. Common at higher and middle elevations.

Haplopappus acaulis **(Nutt.) Gray**

Utah: Garfield Co., 1.3 miles south of Cannonville, Reveal et al. 750. Kane Co., Cockscomb, NDA 3621; Cockscomb, NDA 3584; Buckskin Gulch, SLW 5314. Common.

Haplopappus acradenius **(Greene) Blake** Goldenweed

Arizona: Coconino Co., Lee's Ferry, Clover and Jotter (1941).

Haplopappus armerioides **(Nutt.) T. & G.**

Utah: Garfield Co., Bryce Canyon, Cottam 4357. Kane Co., Smoky Mt., RA 20; 51 miles south of Escalante, NDA 517; Four Mile Bench, SLW & JRM 12404. Locally common.

Haplopappus drummondii **(T. & G.) Blake**

Arizona: Coconino Co., Lee's ferry, NDA 6392. **Utah:** Kane Co., Kane Creek along Colorado River, Buss s. n., 1935; Hole-in-the-Rock, Beck 140; Cottonwood Wash road, SL & SLW 9417; Tibbet Canyon, NDA & DK 3331; Wahweap Creek, NDA et al. 4299. San Juan Co., east of confluence of the San Juan, NDA & RA 3188. Locally common; canyon bottoms.

Haplopappus scopulorum **(Jones) Blake**
Utah: San Juan Co., Ribbon Canyon, NDA 4100; Navajo Mt., NDA & DK 3394. Uncommon to rare; threatened (Welsh et al., 1975).

Helenium hoopesii **Gray** Sneezeweed
Utah: Garfield Co., north of Escalante, McArthur & Beck 188. Uncommon; higher elevations.

Helianthella parryi **Gray**
Utah: San Juan Co., Navajo Mt., NDA et al. 3001; do, Gentry & Davidse 1788. Rare.

Helianthus anomalus **Blake** Sunflower
Utah: Garfield Co., Escalante, Beck & Tanner s. n. Kane Co., Dry Rock Creek, SLW & NDA 11615; Escalante Canyon, SLW & GM 11822; Willow Springs south of Escalante, Harrison 9099. Uncommon; sandy drainages and dunes.

Helianthus petiolaris **Nutt.**
Arizona: Coconino Co., 9.3 miles south of Page, NDA et al. 3347. **Utah:** Garfield Co., Escalante Canyon, McKnight & Beck 201; Cannonville, SLW 9413. Kane Co., 3.3 miles north of Paradise Estates, NDA & RA 2676. San Juan Co., Colorado Canyon, 2 miles below Last Chance, Gaines (1960). Common.

Heterotheca villosa **(Nutt.) Shinners** Golden Aster
Arizona: Coconino Co., Paria Canyon, Woodruff 1124. **Utah:** Kane Co., 43 miles east of Glen Canyon City, NDA et al. 2720; Left-hand fork of Collet Wash, Woodruff 1162; 6 miles west of Glen Canyon City, NDA 2921; Cockscomb, NDA 3615; Hackberry Canyon, NDA & RA 2804; Smoky Mt., NDA et al. 3296; Cedar Mt., NDA 3129a. San Juan Co., Navajo Mt., NDA et al. 2978; Three Garden, NDA & RA 3179. 3185. Ubiquitous; common.

Hymenopappus filifolius **Hook. var. *cinereus*** **(Rydb.) Johnst.**
Utah: Kane Co., Willow Tank, Harrison 9096; 37 miles east of Glen Canyon City, NDA et al. 2710. San Juan Co., Three Garden vicinity, SLW & NDA 11664; Forbidding Canyon, SLW & NDA 11656; Navajo Mt., NDA 4149. Common.

Hymenopappus fillifolius **Hook. var. *nudipes*** **(Maguire) Turner**
Utah: Garfield Co., Pet Hollow, NDA 4330; Escalante Canyon, Beck 118; Escalante, Beck & Tanner s. n. Kane Co., East Clark Bench, Harrison 12071; one mile west of Glen Canyon City, Cronquist 10159; Hole-in-the-Rock, Karren 109; Paria Canyon, Woodruff 1116; Cottonwood Wash road, NDA & RA 2773. San Juan Co., Ribbon Canyon, Lake Powell, NDA 4111. Common.

Hymenoxys acaulis **(Pursh) Parker var. *arizonica*** **(Greene) Parker**
Utah: Garfield Co., 1.3 miles south of Cannonville, Reveal et al. 749; Bryce Canyon, Cottam 4356; 10 miles south of Escalante, Harrison 9121. Kane Co., Cockscomb, NDA 4633; Kaiparowits Plateau, NDA & DT 5249; Paria Townsite, SLW & NDA 9740; Buckskin Gulch, SLW 5315; Nipple Bench, NDA & RA 2812. Common.

Hymenoxys acaulis **(Pursh) Parker var. *ivesiana*** **Greene**
Utah: Garfield Co., Escalante Canyon, McArthur & Beck s. n., June 1940. Kane Co., Four Mile Bench, SLW & JRM 12405; Little Valley Canyon, NDA 3523a; Dry Rock Creek, SLW & NDA 11620; Four Mile Bench, NDA 5173; Fifty Mile Spring, JRM 363; Kaiparowits Plateau, Harrison 9068. San Juan Co., Navajo Mt., Gentry & Davidse 1786; do, NDA 4150. Common.

Hymenoxys cooperi **(Gray) Cockerell**
Utah: Garfield Co., 10 miles south of Escalante, Harrison 9122; Escalante, Stanton 873. Kane Co., Left-hand fork of Collet Wash, Woodruff 1155; 12.7 miles southeast of Cannonville, Horse Mt., north of Four Mile Bench, SLW & JRM 12783. Locally common.

Hymenoxys richardsonii **(Hook.) Cockerell**
Utah: Garfield Co., Bryce Canyon, Cottam 2756; do, Weight s. n., 1934. Uncommon.

Iva axillaris **Pursh**
Utah: Kane Co., Four Mile Bench, NDA 4317. Uncommon.

Lactuca pulchella **(Pursh) Riddel**
Utah: Garfield Co., Bryce Canyon, Weight s. n. Kane Co., Four Mile Creek, SLW et al. 12587. Uncommon.

Lactuca scariola **L.** Prickly Lettuce
Utah: Escalante Canyon, NDA 4118. Uncommon; introduced weed.

Layia glandulosa **(Hook.) H. & A.** Tidy Tips
Arizona: Coconino Co., Cedar Mt., NDA & LCH 3825. **Utah:** Kane Co., Kane-Garfield county line, south of Escalante, NDA & DT 5299; Cedar Mt., NDA 4667. Uncommon.

Lygodesmia grandiflora **(Nutt.) T. & G.** Rush Pink
Utah: Garfield Co., Bryce Canyon, Cottam 2671. Kane Co., Paria River, NDA & LCH 3966; Dry Rock Creek, SLW & NDA 11618; Last Chance Bay, SLW & NDA 11599; Nipple Bench, NDA & RA 2811. Uncommon.

Lygodesmia spinosa **Nutt.**
Utah: Garfield Co., Escalante Canyon, Beck 146. Kane Co., 30 miles east of Kanab, NDA 5586; Four Mile Bench, NDA 4305. Uncommon.

Machaeranthera canescens **(Pursh) Gray**
Arizona: Coconino Co., between Page and Kaibito, Shaw 2643; Paria Plateau, NDA 6425. **Utah:** Kane Co., Cedar Mt., NDA 3130. Common in sandy sites.

Machaeranthera glabriuscula **(Nutt.) Cronq. & Keck var. *confertifolia* Cronq.**
Utah: Kane Co., Four Mile Bench, NDA 5172; Horse Mt., SLW 12819. Endemic, rare, and threatened (Welsh et al., 1975).

Machaeranthera grindelioides **(Nutt.) Shinners**
Utah: Garfield Co., Escalante, Cottam 4400; 8 miles southeast of Escalante, Holmgren et al. 2029. Kane Co., 20 miles south of Cannonville, Christensen s. n., 8 May 1963; Collet Top, Woodruff 1153. Locally common.

Machaeranthera linearis **Greene**
Utah: Garfield Co., Escalante Canyon, McArthur & Beck 198. Kane Co., Reflection Canyon, Lake Powell SLW 11887. Uncommon.

Machaeranthera tanacetifolia **(H.B.K.) Nees**
Utah: Garfield Co., 20 miles southeast of Escalante, Holmgren et al. 2054. Kane Co., Cockscomb, SLW 5349; Paria River, JRM 323; Crosby Canyon, NDA 3633; 6 miles east of Glen Canyon City, SLW & NDA 9759; Sit Down Bench, Olsen 40; Paria River, NDA & LCH 4009; Tibbet Spring, NDA et al. 4272. Common.

Machaeranthera tortifolia **(T. & G.) Cronq.**
Arizona: Coconino Co., upstream from Lee's Ferry, NDA 4588. **Utah:** Kane Co., Smoky Mt., RA 199; 25 miles south of Escalante, Buss 80; Kaiparowits Plateau, Harrison 9072; Cottonwood Wash Road, Cronquist 10208; Last Chance Bay, SLW & NDA 11600; Nipple Creek, RA 258; Little Valley Canyon, NDA 3535; 6 miles east of Glen Canyon City, SLW & NDA 9801; Wahweap Creek, NDA 3484. Common; especially at lower elevations.

Malacothrix glabrata **Gray**
Arizona: Coconino Co., upstream from Lee's Ferry, NDA & LCH 4035. **Utah:** Kane Co., one mile west of Glen Canyon City, Cronquist 10146; Fifty Mile Spring, JRM 362; Little Valley Canyon, NDA 3524a; Warm Creek, NDA 3719. Widespread; common.

Malacothrix sonchioides **(Nutt.) T. & G.**
Arizona: Coconino Co., Page vicinity, SLW & NDA 9782. **Utah:** Kane Co., Willow Tank, Harrison 9101; Kodachrome Flat vicinity, Reveal et al. 800, 6 June 1967; Paria Canyon, Woodruff 1117; 13 miles west of Glen Canyon City, NDA & RA 2858; one mile west of Glen Canyon City, Cronquist 10147; 14 miles east of Glen Canyon City, RWA 198. Common.

Oxytenia acerosa **Nutt.** Copperweed
Utah: Kane Co., Tibbet Canyon, NDA & DK 3413; Four Mile Creek, SLW et al. 12584. Common along stream courses and seeps in saline sites.

Pectis papposa **(Harv.) Gray** Chinchweed
Arizona: Coconino Co., 9.3 miles south of Page, NDA et al. 3351. **Utah:** Kane Co., 55 miles east of Kanab, SL & SLW 9419; 3 miles south of Glen Canyon City, NDA 3129; Escalante Canyon, NDA & RA 3213. Uncommon; widespread at lower elevations.

Perezia wrightii **Gray**
Utah: Kane Co., Nipple Bench, NDA & RA 2815; Kaiparowits Plateau, Woodruff & Meyer 1144; Dry Rock Creek, SLW & NDA 11641; Smoky Mt., NDA 5204. Along canyons; locally common.

Petradoria pumila **(Nutt.) Greene**
Utah: Kane Co., Four Mile Bench, NDA

4307. San Juan Co., Navajo Mt., NDA 4152. Widespread; locally common in rimrock sites.

Pluchea sericea (Nutt.) Cov.

Arizona: Coconino Co., Lee's Ferry, Cottam 2618; do, NDA & LCH 3815. **Utah:** Kane Co., Hole-in-the-Rock, Harrison 12115. Uncommon along the Colorado River.

Psathyrotes pilifera Gray

Arizona: Coconino Co., Lee's Ferry, Cottam 2630. Rare.

Psilostrophe sparsiflora (Gray) A. Nels.

Arizona: Coconino Co., Lee's Ferry, Cottam 2614; south base of Navajo Mt., NDA et al. 3006. **Utah:** Garfield Co., Escalante Canyon, Harrison 9133; Pet Hollow, NDA 4334; 8 miles southeast of Escalante, Holmgren et al. 2021. Kane Co., Cottonwood Wash, NDA & RA 2776; Paria River, NDA & LCH 3953; Four Mile Bench, SLW & JRM 12406. Common, widespread.

Senecio douglasii DC. var. *longilobus* (Benth.) Benson

Utah: Kane Co., Paria River, Holmgren & Holmgren 4710; Cottonwood Wash Road, Reveal & Gentry 832; do, NDA & RA 2770. Uncommon.

Senecio multilobatus T. & G.

Utah: Kane Co., Four Mile Bench, NDA 3757; head of Last Chance Canyon, SLW & JRM 12784. Uncommon.

Senecio spartioides T. & G.

Utah: Garfield Co., Bryce Canyon, Weight s. n.; Escalante, Beck & Tanner s. n. Uncommon.

Solidago canadensis L. Goldenrod

Utah: Kane Co., Escalante Canyon, SLW & GM 11815; Reflection Canyon, SLW & CAT 11847. San Juan Co., Rainbow Bridge, NDA & NW 3304. Local and restricted; uncommon.

Solidago occidentalis (Nutt.) T. & G.

Arizona: Coconino Co., Lee's Ferry, NDA 6390. **Utah:** Kane Co., Reflection Canyon, SLW & CAT 11861. San Juan Co., east of confluence of the San Juan, NDA & RA 3175. Uncommon.

Solidago sparsiflora Gray

Utah: Garfield Co., Pet Hollow, NDA 4333. Kane Co., Driftwood Canyon, SLW & GM 11781. San Juan Co., east of confluence of the San Juan, NDA & RA 3160. Hanging gardens; locally common.

Solidago trinervata Greene

Arizona: Coconino Co., Lee's Ferry, Clover and Jotter (1941). The specimen has not been seen by the present writers, and the report requires confirmation.

Sonchus asper (L.) Hill

Utah: Kane Co., Escalante River, NDA & RA 3208. San Juan Co., Hanging garden, San Juan River, above the confluence, NDA 4099. Uncommon.

Stephanomeria exigua Nutt. Wire Lettuce

Utah: Kane Co., Spencer Flat, southeast of Escalante, NDA 483, 16 June 1965; Church Wells, JRM 328; Paria River, north of US Highway 89, NDA & LCH 3955; do, NDA & RA 2761; NDA et al. 2739. San Juan Co., Three Garden, SLW & NDA 11674. Common.

Stephanomeria parryi Gray

Utah: Kane Co., Nipple Bench, NDA & RA 2822a. Rare.

Stephanomeria tenuifolia (Jones) Hall

Arizona: Coconino Co., Colorado River channel, north of Navajo Canyon, NDA & RA 3141. **Utah:** Kane Co., 3 miles south of Glen Canyon City, NDA 3134; Cottonwood Wash, 12 miles north of Highway 89, NDA & KD 3322; Head of left fork of Last Chance Canyon, NDA et al. 2701. Common; rock outcrops and talus slopes.

Stylocline micropoides Gray

Arizona: Coconino Co., Lee's Ferry, NDA 4568. **Utah:** San Juan Co., Ribbon Canyon, SLW & NDA 11713. Rare.

Taraxacum officinale (L.) Wiggers Dandelion

Utah: Kane Co., Nipple Canyon, RWA 246. Introduced, ubiquitous weed.

Tetradymia canescens DC.

Utah: Kane Co., West side of Cockscomb, NDA 2924; Four Mile Bench, NDA 4068; Buckskin Gulch, NDA 6387. Locally common.

Thelysperma subnudum Gray

Utah: Garfield Co., 8 miles southeast of Escalante, Holmgren et al. 2026. Kane Co., Nipple Bench, NDA & RA 2810. Uncommon.

Townsendia annua Beaman

Arizona: Lee's Ferry, NDA 4578. **Utah:**

Kane Co., Tibbet Canyon, NDA 3605; Tibbet Bench, NDA & DT 5059; Wahweap Bay, NDA 3552; Grand Bench, NDA 4260. Ca 15 miles west of Glen Canyon City, NDA & T. A. 2870. Common, low elevations.

***Townsendia incana* Nutt.**

Utah: Garfield Co., Escalante, Cottam 4402; Ca 8 miles southeast of Escalante, Holmgren et al. 3020; Ca 20 miles southeast of Escalante, Holmgren et al. 2048. Kane Co., Wahweap Creek, Harrison 12087; Kaiparowits Plateau, NDA & DT 5271; Paria River Bridge, SWL & NDA 9753; Paria River, NDA & RA 2777; Glen Canyon City, Cronquist 10156; Cockscomb, SLW 5345; Paria River, NDA & LC Higgins 3968; Paria River, Woodruff 1110; 4 miles south of Cannonville, Cronquist 10082; East Clark Bench, Harrison 12300; Cottonwood Wash, NDA 3589; Cedar Mt., NDA 3114. Abundant; widespread.

***Townsendia exscapa* (Richards.) Porter**

Arizona: Coconino Co., Buckskin Mt., NDA 4943. **Utah:** Garfield Co., Bryce Canyon, Buchanan 1481 (Bryce). Uncommon.

***Townsendia minima* Eastw.**

Utah: Garfield Co., Bryce Canyon, Cottam 5672. Endemic, rare, and possibly threatened (Welsh et al., 1975).

***Vanclevea stylosa* (Eastev.) Greene**

Arizona: Coconino Co., 9.3 miles south of Page, NDA et al., 3339; Colorado River Canyon, north of Navajo Canyon, NDA & RA 3144. **Utah:** Kane Co., 6 miles east of Glen Canyon City, NDA & DK 3355; Fifty Mile Spring, JRM 375; 2 miles south of Glen Canyon City, NDA 3095; East Clark Bench, SL & SLW 9418; Cedar Mt., NDA 6009A. Abundant on sandy sites at lower elevations.

***Verbesina encelioides* (Cov.) Benth. & Hook**

Utah: Garfield Co., Bryce Canyon, Weight B-32/343 (Bryce). Uncommon.

***Viguiera annua* (Jones) Blake**

Utah: Kane Co., Tropic shale, east of Paria River, NDA & LCH 3993; do, NDA & DK 3320; Cottonwood Canyon, SL & SLW 9416. Uncommon.

***Viguiera soliceps* Barneby**

Utah: Kane Co., Tropic shale, 4 miles north of Highway 89 along Cottonwood Wash Road, NDA & RA 2759; 20 miles east of Glen Canyon City, NDA & DT 5073; mouth of Paria Canyon, Cottonwood Wash Road, SLW 11056; do, Reveal & Gentry 833. Note: This plant is considered as endangered (Welsh et al. 1975). It is endemic to the Tropic Shale formation.

***Wyethia scabra* Hook.**

Utah: Kane Co., Willow Tank, Beck & Tanner s. n.; Hall Cave, 50 miles south of Escalante, Beck & Tanner s. n.; East Clark Bench, NDA & RA 2684. San Juan Co., Rainbow Bridge, SLW & NDA s. n. Widespread, uncommon.

***Xanthium saccharatum* Wallr.**

Utah: San Juan Co., Three Garden NDA & RA 3187, 23 Aug. 1971; do, CAT & SLW 166. Locally common.

CONVOLVULACEAE (Morning Glory Family)

***Convolvulus arvensis* L.**

Utah: Kane Co., 15 miles south of Cannonville, NDA & RA 2911. Uncommon.

***Evolvulus nuttallianus* R. & S.**

Utah: Kane Co., Paria River, NDA & LCH 3962; East Clark Bench, Harrison 12299; do, Cronquist, 10174; do, NDA & RA 2669. Uncommon.

CRASSULACEAE (Stonecrop Family)

***Sedum lanceolatum* Torr.**

Utah: San Juan Co., Navajo Mt., NDA et al. 2997; do, NDA 4184. Uncommon.

CRUCIFERAE (Mustard Family)

***Arabis fendleri* (Wats.) Greene**

Arizona: Coconino Co., Buckskin Mt., NDA 4941. **Utah:** San Juan Co., Navajo Mt., NDA 4179. Common.

***Arabis holboellii* Hornem.**

Utah: Kane Co., Kaiparowits Plateau, Harrison 9056. Uncommon.

***Arabis lignifera* A. Nels.**

Utah: Kane Co., Four Mile Bench, NDA 5167; west of Cockscomb, NDA 4611. Uncommon.

***Arabis pendulina* Greene**

Utah: Garfield Co., Four miles southwest of Cannonville, Reveal et al. 776. Kane Co., Four miles south of Cannonville, Cronquist 10080. Uncommon.

Arabis perennans **Wats.**

Utah: Kane Co., Kaiparowits Plateau, Harrison 9054; 29 miles south of Escalante, 10031; Five Mile Mt., NDA 4641; Buckskin Mt., NDA 4653; 4 miles south of Cannonville, Cronquist 10079. Common.

Arabis pulchra **Jones.**

Utah: Kane Co., Smoky Mt., Cronquist 10019; Nipple Bench, NDA 3482; Cockscomb, NDA 4635. Common.

Arabis selbyi **Rydb.**

Utah: Garfield Co., About 4 miles southwest of Cannonville, Reveal et al. 775. Uncommon.

Brassica nigra **(L.) Koch.** Black Mustard

Arizona: Coconino Co., along U.S. Highway 89, NDA 5197. Uncommon.

Capsella bursa-pastoris **(L.) Medic** Shepherds Purse

Utah: Kane Co., Kaiparowits Plateau, NDA & DT 5236. Uncommon.

Caulanthus crassicaulis **(Torr.) Wats.**

Utah: Garfield Co., 1.3 miles south of Cannonville, Reveal et al. 760, Kaiparowits Plateau, NDA & DT 5282; Cockscomb, NDA 4612; Last Chance Creek, NDA 3745; Four Mile Bench, NDA 4065; 25 miles southeast of Escalante, Holmgren et al. 2072; Buckskin Gulch, SLW 5313; Brigham Plains, NDA & RA 2784. Common on benchlands.

Chorispora tenella **(Pall.) DC.**

Utah: Kane Co., Cockscomb, NDA 3629. Introduced weed, uncommon.

Descurainia obtusa **Greene**

Utah: Kane Co., 4 miles below Last Chance Canyon, Gaines (1960).

Descurainia pinnata **(Walt.) Britt.**

Arizona: Coconino Co., west side of Cockscomb, NDA 3055. **Utah:** Kane Co., Little Valley, NDA et al. 2722; Kaiparowits Plateau, Harrison 9044; do, NDA & DT 5287; Smoky Mt. RWA 129; Cedar Mt., RWA 339, 352; Smoky Mt. NDA 3441; Cockscomb, NDA 3588; San Juan Co., Three Garden, SLW 11904. Common to abundant; widespread.

Dithyrea wislizenii **Engelm.**

Arizona: Coconino Co., Colorado River between Lee's Ferry and Glen Canyon Dam, NDA 4590. **Utah:** Kane Co., Wahweap Creek, NDA & DT 3421; Paria River, NDA & LCH 3949; Warm Creek, RWA 114; 2 miles west of Glen Canyon City, Nebeker & Skougard 184; 5 miles W. of Glen Canyon City, NDA 3115; 13 miles west of Glen Canyon City, NDA & RA 2857; Cockscomb, NDA 3579; ½ mile west of Paria River Bridge, SLW & NDA 9755. Locally common, in sandy sites.

Draba cuneifolia **Nutt.**

Utah: Kane Co., Four Mile Bench, NDA 3486; Five Mile Mt., NDA 4412; Kaiparowits Plateau, NDA & DT 5272. Uncommon; widespread at lower elevations.

Draba subalpina **Goodman & Hitchc.**

Utah: Garfield Co., Bryce Canyon, Buchanan 2073, (Bryce); do SLW 12724; do SLW 12808. Rare; threatened (Welsh et al. 1975).

Erysimum asperum **Nutt.**

Arizona: Coconino Co., Arizona, 3 miles south of Wahweap Marina, SLW & NDA 9760. **Utah:** Garfield Co., Bryce Canyon, Boyle 1107; do, Burkey 126. Kane Co., one mile south of Glen Canyon City, NDA 3432; Five Mile Mt., NDA 4683; Kaiparowits Plateau, NDA & DT 5234; Cockscomb, NDA 3590; Cedar Mt., NDA 3432; Four Mile Bench, SLW & JRM 12407; Cockscomb, NDA 3541; 14 miles east of Glen Canyon City, RWA 168. Common.

Hutchinsia procumbens **(L.) Desv.**

Utah: San Juan Co., Ribbon Garden, SLW & NDA 11705; Three Garden, SLW 11907. Uncommon.

Lepidium densiflorum **Schrad.**

Arizona: Coconino Co., Colorado River, between Lee's Ferry and Glen Canyon Dam, NDA 4585. **Utah:** Kane Co., Little Valley, NDA 3523; Kaiparowits Plateau, NDA & D. Trotter 4272; Cockscomb, NDA 3587. Common.

Lepidium montanum **Nutt. var. *alyssioides* (Gray) Jones**

Utah: Kane Co., Kodachrome Flats vicinity, Reveal et al. 789. Uncommon.

Lepidium montanum **Nutt. var. *glabrum* C. L. Hitchc.**

Utah: Kane Co., Paria River Canyon, JRM M106; Tibbet Spring, RWA 112;

Smoky Mt., RWA 167; Fifty Mile Spring, JRM 368; Cedar Mt., NDA et al. 1746. Common and widespread.

***Lepidium montanum* Nutt. var. *integrifolium* (Nutt.) C. L. Hitchc.**

Arizona: Coconino Co., Lee's Ferry, NDA 6391. Uncommon.

***Lepidium montanum* Nutt. var. *jonesii* (Rydb.) C. L. Hitchc.**

Arizona: Coconino Co., Cedar Mt., RWA 170. **Utah:** Kane Co., 20 miles south of Cannonville, Christensen s.n.; Willow Tank, Harrison 9028; do, White 112; Tibbet Canyon, NDA 3444; Nipple Canyon, RWA 244; Collet Canyon, Woodruff 1159; Paria River, NDA & LCH 3975. Common and widespread.

***Lepidium perfoliatum* L.**

Utah: Kane Co., Nipple Bench vicinity, LCH & NDA 5244; Cockscomb, NDA 3617. Uncommon, introduced weed.

***Lesquerella intermedia* (Wats.) Heller**

Arizona: Coconino Co., Cockscomb, NDA et al. 3008. Uncommon.

***Lesquerella kingii* Wats. ssp. *latifolia* (A. Nels.) Rollins & Shaw**

Utah: Garfield Co., Canyon above Tropic, Jones 5312d (US); Bryce Canyon, Weight s.n., 1932 (US).

***Lesquerella ludoviciana* (Nutt.) S. Wats.**

Utah: Garfield Co., Ca 6 miles southeast of Escalante, Karren 121. Uncommon.

***Lesquerella rectipes* Woot. & Standl.**

Arizona: Coconino Co.; Cockscomb, NDA & RA 2887; do, NDA 3064. **Utah:** Kane Co., Last Chance Creek, NDA 3749; Cockscomb, NDA 3580. San Juan Co., Navajo Mt., NDA 4139. Common.

***Lesquerella rubicundula* Rollins.**

Utah: Garfield Co., Bryce Canyon, observed but not collected (see Reveal 1970); rare and threatened (Welsh et al., 1975).

***Lesquerella tumulosa* (Barneby) Reveal**

Utah: Kane Co., 6.5 miles southeast of Cannonville, SLW 12765. Endemic, rare, and threatened (Welsh et al., 1975).

***Lesquerella wardii* Wats.**

Utah: Kane Co., Four Mile Bench, SLW & NDA 12379. Uncommon.

***Malcolmia africana* (L.) R. Br.**

Arizona: Coconino Co., Colorado River Canyon, between Glen Canyon Dam and Lee's Ferry, NDA & LCH 4029. **Utah:** Kane Co., Paria River, NDA & LCH 3963. Uncommon to very common introduced weed.

***Nasturtium officinale* R. Br.**

Arizona: Coconino Co., Paria primitive area, Woodruff 1133. Rare; watercress.

***Physaria chambersii* Rollins**

Utah: Kane Co., Last Chance Creek, NDA 3748; Horse Mt., SLW & NDA 12373; Paria River, NDA & LCH 3980; Warm Creek RWA 116; Brigham Plains NDA et al. 3490; Buckskin Gulch 5318. Common.

***Physaria newberryi* Gray**

Utah: Garfield Co., Bryce Canyon, Burkey 138; 6 miles north of Escalante, White 145. Kane Co., Kaiparowits Plateau, JRM 403. Common.

***Schoencrambe linifolia* (Nutt.) Greene**

Utah: Kane Co., Smoky Mt., Cronquist 10018; Paria Townsite, SLW & NDA 9734; Last Chance Creek, NDA et al. 3514; Kaiparowits Plateau, Olson 41; do, NDA & DT 5238; Smoky Mt., NDA 3441; do, RWA 132; Cockscomb, NDA 4623. Common; widespread.

***Sisymbrium altissimum* L.**

Utah: Kane Co., Buckskin Mt., NDA 4651. Uncommon.

***Stanleya pinnata* (Pursh) Britt.**

Utah: Garfield Co., 6 miles southeast of Escalante, NDA 466; Escalante, Cottam 4422. Kane Co., 50 miles southeast of Escalante, Beck s.n.; Paria Townsite, SLW & NDA 9722; 31 miles east of Glen Canyon City, NDA et al. 2696; Kaiparowits Plateau, Woodruff 1146. San Juan Co., San Juan River Canyon, east of the confluence, NDA 4087. Common selenophyte; widespread.

***Streptanthella longirostris* (Wats.) Rydb.**

Arizona: Coconino Co., Colorado River between Lee's Ferry and Glen Canyon Dam, NDA 4592; 4 miles southeast of Page, RWA 235. **Utah:** Kane Co., Warm Creek SLW & NDA 9798; Nipple Bench vicinity, Cronquist 10015; East Clark Bench, Harrison 12074; 4 miles east of Glen Canyon City, RWA 118; Smoky Mt., RWA 130; Willow Tank, Harrison 9091; 2 miles south of Cannonville, Reveal et al. 779. Common; widespread.

Streptanthus cordatus **Nutt.**

Utah: Kane Co., Grand Bench, NDA 3533; Kaiparowits Plateau, NDA & DT 5281; Five Mile Mt., NDA 4640. Common.

Thelypodium integrifolium **(Nutt.) Endl.**

Utah: Kane Co., head of Last Chance Canyon, SLW et al. 12597; Lake Powell, NDA 3137. San Juan Co., San Juan River, east of the confluence, NDA & RA 3150. Uncommon.

Thelypodium sagittatum **(Nutt.) Endl. var.** ***ovalifolium*** **(Rydb.) Welsh & Reveal**

Utah: Garfield Co., Bryce Canyon, Eastwood & Howell 766 (CAS), fide Al-shebaz (1973). Uncommon.

Thlaspi arvense **L.**

Utah: Kane Co., Bryce Canyon, NDA 6125. Introduced weed; uncommon.

Thlaspi montanum **L.**

Utah: Garfield Co., Death Ridge, NDA 5183. High elevations; uncommon.

CUPRESSACEAE (Cypress Family)

Juniperus communis **L.**

Utah: Garfield Co., Bryce Canyon, Burkey 128, San Juan Co., Navajo Mt., NDA 4181. Uncommon; higher elevations.

Juniperus osteosperma **(Torr.) Little**

Arizona: Coconino Co., 8 miles southeast of Page, NDA et al. 3246. **Utah:** Garfield Co., Escalante, Beck & Tanner s.n. Kane Co., Kaiparowits Plateau, Harrison 9079; 6 miles east from Glen Canyon City, SLW & NDA 9806; Four Mile Bench, SLW & ERW 12368; Nipple Canyon, RWA 259. San Juan Co., Navajo Mt. NDA et al. 3004; Ribbon Garden, SLW & NDA 11708. Common at middle elevations.

Juniperus scopulorum **Sarg.**

Utah: Kane C., Canaan Peak vicinity, common but not collected; San Juan Co., Navajo Mt., NDA et al. 2981. Middle elevations.

CUSCUTACEAE (Dodder Family)

Cuscuta cephalanthii **Engelm.**

Utah: Kane Co., Hole-in-the-Rock, Beck 138. Rare.

CYPERACEAE (Sedge Family)

Carex curatorum **Stacey**

Utah: San Juan Co., Three Garden, SLW 12425. New Utah Record; rare and threatened (Welsh et al., 1975).

Carex douglasii **Britt.**

Utah: Garfield Co., Bryce Canyon, Buchanan 66. (Bryce). Uncommon.

Carex eleocharis **Bailey**

Utah: Garfield Co., Bryce Canyon, Burkey 144. Uncommon.

Carex garberi **Fern.**

Utah: Kane Co., Little Valley Canyon, SLW & NDA 11613; San Juan Co., Ribbon Garden, SLW & NDA 11714. Local in hanging gardens.

Carex kelloggii **Boott**

Utah: San Juan Co., Mystery Canyon, Gaines (1960).

Carex haydeniana **Olney**

Utah: Garfield Co., Escalante Canyon, Cottam 4426. Uncommon.

Carex lanuginosa **Michx.**

Utah: Kane Co., Hole-in-the-Rock, Harrison 12121. Uncommon.

Carex nebraskensis **Dewey**

Utah: Garfield Co., Escalante Canyon, Cottam 4377. Uncommon

Carex rossii **Boott.**

Utah: San Juan Co., Navajo Mt., NDA 4161. Uncommon.

Carex scirpiformis **Mack.**

Utah: Kane Co., Hd. Mill Fk., east fork of Sevier River, Lewis s.n. Uncommon.

Carex vesicaria **L.**

Utah: San Juan Co., Escalante Canyon, NDA 4124. Uncommon.

Cladium californicum **(Wats.) O'Neill**

Utah: Kane Co., Driftwood Canyon, SLW & NDA 11709; do, SLW & GM 11780; Hidden Passage Canyon, SLW & CAT, 11870; San Juan Co., Utah, Wilson Creek, SLW & CAT 11874. Rare and threatened (Welsh et al., 1975).

Cyperus schweinitzii **Torr.**

Arizona: Coconino Co., Cockscomb, NDA et al. 3009a, do, NDA, 3070. Uncommon.

Eleocharis palustris **(L.) R. & S.**

Utah: Garfield Co., Escalante River, Beck s.n. Kane Co., Cottonwood Wash, Reveal et al. 820; Willow Tank, Beck s.n. Locally abundant.

***Eleocharis rostellata* Torr.**
Utah: San Juan Co., Three Garden, SLW & NDA 11669; do, SLW 112437. Local and uncommon.

***Fimbristylis puberula* (Michx.) Vahl**
Utah: Kane Co., north of Iceberg Canyon, NDA & NW 3311. Uncommon.

***Fimbristylis thermalis* Wats.**
Utah: Kane Co., north of Iceberg Canyon, NDA & NW 3311; Long Garden, Escalante River, SLW & CAT 11873. Rare. Uncommon.

***Scirpus acutus* Muhl.**
Utah: Kane Co., Paradise Canyon, Welsh et al. 12601, Escalante Canyon, NDA 4223; first hanging garden mouth of Escalante River, SLW & GM 11814. Uncommon.

***Scirpus americanus* Pers.**
Arizona: Coconino Co., Paria River, NDA 4008; do. **Utah:** Kane Co., Ca .6 miles south of Nipple Spring, NDA & RA 2831; do, Four Mile Bench, NDA 4310; Paradise Canyon, SLW et al. 12595; Willow Tank, Harrison 9105; Cottonwood Wash Spring, Reveal et al. 822.

***Scirpus paludosus* A. Nels.**
Utah: Kane Co., Tibbet Spring, NDA & Kaneko 3415. Rare.

ELAEAGNACEAE (Oleaster Family)

***Elaeagnus augustifolia* L.** Russian Olive
Utah: Kane Co., 16 miles north of gravel pit in Wahweap Creek, NDA 3471. Introduced weedy tree.

***Shepherdia argentea* (Pursh) Nutt.** Silver Buffaloberry
Utah: Garfield Co., 3 miles north of Escalante, Maguire s.n., Kane Co., Head of Last Chance Canyon, NDA et al. 3508. Uncommon.

***Shepherdia canadensis* (L.) Nutt.**
Utah: Garfield Co., Bryce Canyon, Weight B-32/256. Rare.

***Shepherdia rotundifolia* Parry**
Utah: Garfield Co., Escalante, Cottam 4374; do, Beck & Tanner s.n. Kane Co., 50 miles south of Escalante, Beck & Tanner s.n.; 32 miles south of Escalante, Cronquist 10029; 6 miles southeast of Canaan Peak, SLW & NDA 12370; Paria Townsite, Patton 124; do, SLW & NDA 9723; Kaiparowits Plateau, JRM 397; do, Harrison 9078; do, NDA & DT 5294; 20 miles south of Cannonville, Christensen s.n., Paria River, NDA & LCH 4002; 31.5 miles east of Glen Canyon City, NDA et al. 2704; 10 miles southeast of Cannonville, NDA et al. 3505b; 8 miles south of Paria, Harrison 12048. Abundant to common; widespread.

EPHEDRACEAE (Jointfir Family)

***Ephedra cutleri* Peebles**
Arizona: Coconino Co., one mile east of Page, NDA & LCH 4019; 4 miles southeast of Page, RWA 215. **Utah:** Kane Co., Last Chance Bay, Lake Powell, SLW & NDA 11607, 20 miles east of Glen Canyon City, NDA 4061; 7 miles southeast of Glen Canyon City, RWA 227; one mile west of Glen Canyon Dam, NDA 3573.

***Ephedra torreyana* Wats.**
Arizona: Coconino Co., Colorado river Canyon, between Glen Canyon Dam and Lee's Ferry, NDA & LCH 4041. **Utah:** Garfield Co., 8 miles southeast of Escalante, Holmgren et al. 2037. Kane Co., Wahweap Creek, Harrison 12100; Warm Creek vicinity, Lake Powell, NDA 3721; East Clark Bench, NDA & RA 2689; Gunsight Bay, Lake Powell, SLW & NDA; Paria River, NDA & LCH 4016, Hole-in-the-Rock, Harrison 12141. Widespread; common.

***Ephedra viridis* Coville** Green Mormon-Tea
Utah: Garfield Co., Escalante, Cottam 4380; 28 miles southeast of Escalante, Harrison 9119. Kane Co., Willow Tank, Paria Townsite, Olson 27; 4½ miles south of Glen Canyon City, RWA 331; Fifty Mile Spring, JRM 365; Cedar Mt., NDA et al. 2747a. San Juan Co., Ribbon Garden, SLW & NDA 11697. Abundant; widespread.

EQUISETACEAE (Horsetail Family)

***Equisetum arvense* L.**
Utah: Garfield Co., Escalante Canyon, Beck, s.n., Kane Co., Paria River, NDA & LCH 4012; Hackberry Canyon, NDA 3686, 3697. Uncommon.

***Equisetum hyemale* L.**
Utah: San Juan Co., Rainbow Bridge, SLW & NDA 11660. Uncommon.

ERICACEAE (Heather Family)

***Arctostaphylos patula* Greene** Manzanita
Utah: Garfield Co., Bryce Canyon, White 151; do, Burkey 127; Cockscomb, NDA 3538; do, NDA 3596; Kaiparowits Plateau; Harrison 9082. Local; uncommon.

EUPHORBIACEAE (Spurge Family)

***Croton texensis* (Klotzsch) Meuell. Arg.**
Arizona: Coconino Co., Paria Plateau, NDA 6411. **Utah:** Kane Co., 6 miles east of Glen Canyon City, NDA & DK 3359; Glen Canyon City vicinity, NDA 2915; Halls Creek Bay, Lake Powell, SLW & GM 11795; Warm Creek Bay, NDA, 3288a; Paria Primitive Area, NDA & RA 2860. Common; sandy sites at low elevations.

***Euphorbia albomarginata* T. & G.**
Utah: Garfield Co., Escalante Canyon, Harrison 9124. Kane Co., Cedar Mt., RWA 441. Uncommon.

***Euphorbia fendleri* T. & G.**
Arizona: Coconino Co., mile 6 A on Lake Powell, NDA 3700. **Utah:** Garfield Co., 8 miles southeast of Escalante, Holmgren et al. 2020; Escalante, Beck & Tanner s.n. Kane Co., Willow Tank, Beck & Tanner s.n.; Ahlstrom Point road, NDA & RA 2894; Kaiparowits Plateau, Woodruff 1148; head of Last Chance Canyon, Cronquist 10027; 4 miles south of Cannonville, Reveal et al. 786. Common.

***Euphorbia glyptosperma* Englem.**
Arizona: Coconino Co., Paria Plateau, NDA & GM 4278. **Utah:** Kane Co., Cedar Mt., NDA 3100. Uncommon.

***Euphorbia nephradenia* Barneby**
Utah: Kane Co., Cottonwood Wash Road, 5.4 miles north of U.S. 89, Reveal and Gentry 834; Paria Primitive Area, NDA & RA 2865; 6 miles south of confluence of Cottonwood Canyon, SLW 11059. Endemic, rare, and threatened (Welsh et al., 1975).

***Euphorbia robusta* (Englem.) Small**
Utah: Kane Co., Kaiparowits Plateau, Harrison 9037a, 9042; do, NDA & DT 5231. Uncommon.

***Reverchonia arenaria* Gray.**
Arizona: Coconino Co., Paria Plateau, NDA 6426. **Utah:** Kane Co., Cedar Mt., NDA 3128; Glen Canyon City vicinity, NDA 2920. Rare.

FAGACEAE (Beech Family)

***Quercus gambelii* Nutt.**
Arizona: Coconino Co., Paria Plateau, NDA & GM 4293, **Utah:** Kane Co., Hackberry Canyon, NDA 3689; Kaiparowits Plateau, NDA & DT 5267; Escalante River, SLW & GM 11820; Hole-in-the-Rock, Harrison 12732; do, Harrison 12134; Reflection Canyon, SLW & CAT 11854; Escalante River, NDA 4119. San Juan Co., confluence of San Juan Canyon, NDA 4093; Three Garden, SLW & NDA 11684. Common in canyons, and on higher mountain slopes.

***Quercus turbinella* Greene**
Arizona: Coconino Co., Paria Plateau, NDA & G. Moore 4398. **Utah:** San Juan Co., Three Garden, SLW & NDA 11684 A. Rare.

***Quercus undulata* Torr.**
Utah: Kane Co., Dance Hall Rock, JRM 381, 382; 50 miles south of Escalante, Beck & Tanner s.n.; Willow Tank, Beck & Tanner s.n. do, Harrison 9087; Escalante Canyon, SLW & GM 11825, 11826; do, NDA 4220; 60 miles south of Escalante, Harrison 12723; Hole-in-the-Rock, White 125; Cockscomb, NDA 3544; do, SLW 5334. Common.

FUMARIACEAE (Fumitory Family)

***Corydalis aurea* Willd.**
Arizona: Coconino Co., Paria Plateau, NDA & LCH 3774. **Utah:** Kane Co., Brigham Plains, NDA et al. 2489. San Juan Co., Navajo Mt., NDA 4138. Widespread; uncommon.

GENTIANACEAE (Gentian Family)

***Centaurium exaltatum* (Griseb.) Wight**
Utah: Kane Co., head of Last Chance Canyon, SLW et al. 12593; San Juan Co., Three Garden, SLW & CAT 11866. Rare.

***Frasera albomarginata* Wats.**
Utah: Garfield Co., Escalante, Cottam 4403. Kane Co., 45 miles east of Glen Canyon City, NDA et al. 2728; Four Mile Bench, NDA 4070; Brigham Plains, NDA &

RA 2786; 25 miles southeast of Escalante, Holmgren et al. 2063. Uncommon.

***Frasera paniculata* Torr.**

Utah: Kane Co., East Clark Bench, NDA & RA 2687; do, NDA & RA 2876. Rare.

***Gentiana affinis* Griseb.**

Utah: Kane Co., Wahweap Creek, Four Mile Bench, SLW 12572. Rare.

***Gentianella tortuosa* (Jones) Gillett**

Utah: Garfield Co., Bryce Canyon, Cottam 2765; do Weight s.n. Rare.

GERANIACEAE (Geranium Family)

***Erodium cicutarium* (L.L) L'Her.** Storksbill

Utah: Kane Co., Cockscomb, NDA 3628; Little Valley, NDA 3431; Kaiparowits Plateau, NDA & DT 5274. Introduced weed; widespread and locally abundant.

***Erodium texanum* Gray**

Arizona: Coconino Co., Lee's Ferry, Cottam 10004.

***Geranium marginale* Rydb.**

Utah: Garfield Co., Bryce Canyon, Buchanan 1716 (Bryce). Rare and possibly threatened (Welsh et al., 1975).

***Geranium richardsonii* Fisch & Trautv.**

Utah: Garfield Co., Escalante Canyon, VanCott 982. Kane Co., between Death Ridge & Canaan Peak, SLW et al. 12590. Uncommon.

GRAMINEAE (Grass Family)

***Agropyron caninum* (L.) Beauv. var. *andinum* (Scribn. & Sm.) C.L. Hitchc.**

Utah: Garfield Co., 15 miles southeast of Escalante, Hall 13569. Uncommon.

***Agropyron caninum* (L.) Beauv. var. *latiglume* (Scribn. & Sm.) C.L. Hitchc.**

Utah: Garfield Co., 15 miles southwest of Escalante, Hall 13604; Bryce Canyon, Boyle 1141. Uncommon.

***Agropyron cristatum* (L.) Gaertn.** Crested Wheatgrass

Utah: Garfield Co., 15 miles southwest of Escalante, Hall 13571. Introduced forage grass.

***Agropyron dasystachyum* (Hook.) Scribn.**

Utah: Garfield Co., Escalante Canyon, Beck s.n. Uncommon.

***Agropyron intermedium* (Host.) Beauv.**

Utah: Kane Co., east of Kanab; NDA 3279A. Introduced forage grass.

***Agropyron repens* (L.) Beauv.** Quackgrass

Utah: Kane Co., Last Chance Canyon, east of Four Mile Bench, SLW et al. 12595. Uncommon.

***Agropyron smithii* Rydb.** Western Wheatgrass

Utah: Garfield Co., 15 miles southwest of Escalante, Hall 13575; Bryce Canyon, Boyle 1142; do, Cottam & Hutchings 2773. Common at middle elevations.

***Agropyron spicatum* (Pursh) Scribn. & Sim.**

Utah: Garfield Co., 15 miles southeast of Escalante, Hall 13561. Kane Co., Kaiparowits Plateau, NDA & DT 5251. Uncommon.

***Agrostis alba* L.**

Utah: Garfield Co., 15 miles southwest of Escalante, Hall 13560. Kane Co., Four Mile Bench, SLW et al. 12588; do, NDA 4313. Locally abundant.

***Agrostis semiverticillata* (Forsk.) C. Christ.**

Utah: Kane Co., Hole-in-the-Rock, Harrison, 12136; Escalante River, SLW & GM 11823; do, NDA 4120, 4130. San Juan Co., Ribbon Canyon, NDA 4104. Widespread; canyon bottoms.

***Andropogon barbinodis* Lag.**

Utah: Kane Co., Escalante River, NDA 4219; 2 miles north of confluence of San Juan and Colorado canyons, SL & SLW 11881. San Juan Co., Rainbow Bridge, NDA 4356; east of San Juan confluence, NDA & RA 3165. Uncommon.

***Andropogon glomeratus* (Walt.) B. S. P.**

Utah: Kane Co., Hole-in-the-Rock, Harrison 12131; Reflection Canyon, SLW 11889; east of San Juan confluence, NDA & RA 3161. Rare and threatened (Welsh et al., 1975).

***Andropogon hallii* Hack.**

Utah: Kane Co., Reflection Canyon, observed but not collected (SLW). Uncommon.

***Aristida adscensionis* L.**

Arizona: Coconino Co., Cockscomb NDA & DK 3381. Uncommon.

***Aristida arizonica* Vasey**

Utah: Kane Co., NDA 3131. Rare.

***Aristida fendleriana* Steud.**

Utah: Kane Co., Escalante River, NDA & RA 3201; Dry Rock Creek, Lake Powell, SLW & NDA 11637; Willow Tank, Harrison 9110; Cottonwood Wash, NDA & RA 2774. San Juan Co., east of San Juan confluence, NDA et al. 3227. Common.

Aristida glauca **(Nees) Walt.**

Utah: Garfield Co., Escalante Canyon, Harrison 9130. Kane Co., 35 miles southeast of Escalante, Harrison 9116; Gunsight Bay, Lake Powell, SLW & NDA 11596; Rainbow Bridge SLW & NDA 11654; Hole-in-the-Rock, Harrison 12143; Willow Tank, Beck & Tanner s.n. San Juan Co., east of the San Juan confluence, NDA 4095; confluence of the San Juan, SLW 11935. Common.

Aristida longiseta **Steud.**

Arizona: Coconino Co., Colorado River Canyon north of Navajo Canyon, NDA & RA 3140. **Utah:** Garfield Co., Escalante Desert, Beck s.n. Kane Co., Dry Rock Creek, Lake Powell, SLW & NDA 11622; Cedar Mt., NDA 3127; Cockscomb, JRM 335. Common.

Bouteloua aristidoides **(H.B.K.) Girseb.**

Utah: Kane Co., Cedar Mt., NDA et al. 3254. Rare.

Bouteloua barbata **Lag.**

Arizona: Coconino Co., Navajo Canyon, NDA & RA 3221. **Utah:** Kane Co., East Clark Bench, NDA & DK 3373. Locally common.

Bouteloua curtipendula **(Michx.) Torr.**

Arizona: Coconino Co., Colorado River Canyon, north of Navajo Canyon, NDA & RA 3138. **Utah:** Kane Co., 6 miles east of Glen Canyon City, NDA & DK 3354; Dry Rock Creek, Lake Powell, SLW & NDA 11621. San Juan Co., east of San Juan confluence, NDA 4269; San Juan confluence, SLW 11934. Uncommon.

Bouteloua eriopoda **Torr.**

Arizona: Coconino Co., Colorado River Canyon, north of Navajo Canyon, NDA & RA 3139; Paria Plateau, NDA 6423. **Utah:** Kane Co., Cedar Mt., NDA et al. 32521 do, NDA 3104, do, NDA et al. 2961; Nipple Bench, NDA & DK 3327; East Clark Bench, NDA & DT 3363. Common at lower elevations.

Bouteloua gracilis **(H.B.K.) Lag.**

Arizona: Coconino Co., 6 miles south of Page, NDA et al. 3238; Paria Plateau, NDA 6422; Cockscomb, NDA & DK 3385. **Utah:** Kane Co., Cedar Mt., RWA 179; do, NDA et al. 3251; do, NDA 3133. Common.

Bromus anomalus **Rupr.**

Utah: Garfield Co., Bryce Canyon, Buchanan 54; do, Weight s.n. Uncommon.

Bromus carinatus **Hook. & Arn.**

Utah: Kane Co., Paria River, LCH & NDA 5393; do, NDA 4004. Uncommon.

Bromus inermis **Leyss.**

Utah: Garfield Co., Bryce Canyon, Boyle 1130. Introduced forage grass.

Bromus marginatus **Nees**

Utah: Garfield Co., Escalante Canyon vicinity, Harrison 9147. Kane Co., Cottonwood Wash, NDA 3688. Uncommon.

Bromus porteri **(Coulter) Nash**

Utah: Garfield Co., 15 miles southwest of Escalante, Hall 13584; Bryce Canyon, Weight s.n.; do, Boyle 1139. Uncommon.

Bromus rigidus **Roth**

Utah: San Juan Co., Rainbow Bridge, SLW & NDA 11655. Uncommon.

Bromus rubens **L.**

Arizona: Coconino Co., Colorado Canyon, between Lee's Ferry and Glen Canyon Dam, NDA 4594. **Utah:** Kane Co., Wahweap Creek, Harrison 12097; Little Valley Canyon, NDA et al. 2716; Fifty Mile Spring, JRM 374; Kaiparowits Plateau, Bingham 32. San Juan Co., Three Garden, SLW et al. s.n. Warm Creek, Olson 31; Dry Rock Creek, Lake Powell, SLW & NDA 11629. Abundant.

Bromus tectorum **L.**

Arizona: Coconino Co., Colorado Canyon, between Lee's Ferry and Glen Canyon Dam, NDA & LCH 4040. **Utah:** Kane Co., 50 miles south of Escalante, Beck & Tanner s.n.; Paria River, NDA & LCH 3995; Little Valley Canyon, NDA & SLW 2717A; Kaiparowits Plateau, NDA & DT 5255. San Juan Co., Rainbow Bridge, SLW & NDA 11651; Navajo Mt., NDA 4147. Abundant.

Calamagrostis scopulorum **Jones**

Utah: Garfield Co., Bryce Canyon, Boyle 1153; Kane Co., Last Chance Canyon, NDA et al. 2702. San Juan Co., Rainbow Bridge, NDA & NW 3300; east of San Juan confluence, NDA & RA 3164. Local and uncommon.

Dactylis glomerata **L.** Orchard Grass

Utah: Kane Co., Bryce Canyon, Boyle

1133; Grand Bench,NDA 4262. Introduced forage grass.

Distichlis stricta **(Torr.) Rydb.**

Utah: Kane Co., Hole-in-the-Rock, Harrison 12126; Paria Primitive area, NDA & RA 2875A. Widespread in saline sites at lower elevations.

Elymus canadensis **L.**

Utah: Kane Co., Escalante Canyon, NDA 4260, 4209; mile 47, Lake Powell, NDA et al. 3224. San Juan Co., Three Garden, SLW & CAT 11867; Ribbon Canyon, NDA 4110. Widespread; uncommon.

Elymus salina **Jones**

Utah: Garfield Co., Bryce Canyon, Harrison 11044; Escalante Mts., Stanton 773; 15 miles southwest of Escalante, Hall s.n.; Kane Co., Kaiparowits Plateau, NDA & DT 5252. Widespread; uncommon.

Elymus triticoides **Buckl.**

Utah: San Juan Co., Ribbon Garden, SLW & NDA 11695. Rare.

Festuca elatior **L.**

Utah: Garfield Co., Bryce Canyon, Weight s.n.; 15 miles southwest of Escalante, Hall 13596. Introduced forage grass.

Festuca octoflora **Walt.** Six-weeks Fescue

Arizona: Coconino Co., 4 miles southeast of Page, RWA 233; Colorado Canyon, between Lee's Ferry and Glen Canyon Dam, NDA 4596; 1 mile west of Glen Canyon Dam, NDA 3446. **Utah:** Kane Co., Kaiparowits Plateau, Harrison 9036; 14 miles east of Glen Canyon City, RWA 336; Cedar Mt., RWA 340; Grosvenor Arch, Reveal et al. 806. San Juan Co., Three Garden, SLW & NDA 11700; do, SLW 11900. Abundant.

Glyceria elata **(Nash) Hitchc.**

Utah: Kane Co., Brigham Plains, NDA & RA 2796. Rare.

Glyceria striata **(Lam.) Hitchc.**

Utah: Garfield Co., northeast of Escalante, Harrison 12345. Rare.

Hilaria jamesii **(Torr.) Benth.** Galleta

Arizona: Coconino Co., Cockscomb, NDA & RA 2882. **Utah:** Garfield Co., 50 miles south of Escalante, Beck & Tanner s.n. Kane Co., Willow Tank, Beck & Tanner s.n.; Cedar Mt., NDA 3127A; do, RWA 178; Wahweap Bay, NDA 3554; 14 miles east of Glen Canyon City, RWA 317; Nipple Canyon, RWA 251; Dance Hall Rock, JRM 383; Hole-in-the-Rock, Harrison 12118; Willow Tank, Harrison 9084; Kaiparowits Plateau; Bingham 33, Dry Rock Creek, Lake Powell, SLW & NDA 11636; East Clark Bench, NDA & DK 3369; Warm Creek Olsen 33; Halls Creek Bay, Lake Powell, SLW & GM, 11790; Gunsight Bay, Lake Powell, SLW & NDA 11594; Sit Down Bench, Patton 117, Paria Townsite, JRM 320. Abundant.

Hordeum glaucum **Steud.**

Utah: Kane Co., Paria Townsite, JRM 315. Rare.

Hordeum jubatum **L.**

Utah: Garfield Co., Escalante, Beck & Tanner s.n. Locally common.

Imperata brevifolia **Vasey**

Utah: San Juan Co., Wilson Creek, Lake Powell, SLW 12356, 12356a. Rare, endangered, or possibly extinct (Welsh et al., 1975).

Koeleria nitida **Nutt.**

Utah: Garfield Co., Bryce Canyon, Boyle 1144; 15 miles southwest of Escalante, Hall 13588; 18 miles southwest of Escalante, Hall 13577. Uncommon.

Muhlenbergia andina **(Nutt.) Hitchc.**

Utah: Kane Co., Escalante River, NDA 4226; Four Mile Creek, SLW et al. 12578a; Paradise Canyon, SLW et al. 12598. Uncommon.

Muhlenbergia asperifolia **(Nees & Mey.) Parodi**

Utah: Kane Co., Tibbet Spring, NDA & DK 3416; Four Mile Creek, SLW et al. 12578. San Juan Co., east of San Juan confluence. NDA & RA 3177. Uncommon; saline seeps.

Muhlenbergia curtifolia **Scribn.**

Utah: Kane Co., Mile 47, Lake Powell, NDA et al. 3233. Local, uncommon, and possibly threatened (Welsh et al., 1975).

Muhlenbergia pungens **Thurb.**

Arizona: Coconino Co., between Page and Kaibito, Shaw 2648; Paria Plateau, NDA 6415. **Utah:** Kane Co., Cedar Mt., NDA 3103; Gunsight Bay, Lake Powell, SLW & NDA 11592. Common.

Munroa squarrosa **(Nutt.) Torr.**

Arizona: Coconino Co., Paria Plateau, NDA 6421; Cockscomb, NDA 3062; Lee's Ferry, NDA 4569; 9.3 miles south of Page, NDA et al. 3352. **Utah:** Kane Co., Cedar Mt., NDA 3103; Gunsight Bay, Lake Powell, SLW & NDA 11592. Common.

Oryzopsis bloomeri **(Boland.) Ricker**

Arizona: Coconino Co., Lee's Ferry vicinity, NDA 5210. **Utah:** Kane Co., Kaiparowits Plateau, NDA & DT 5259; Paria Townsite, JRM 313. Rare.

Oryzopsis hymenoides **(R. & S.) Ricker**

Arizona: Coconino Co., ca 5 miles south of Page, RWA 230. **Utah:** Kane Co., 50 miles south of Escalante, Beck & Tanner, s.n.; Cedar Mt., NDA & LCH 3827; do., NDA 3113, Hole-in-the-Rock, Harrison 12130; Willow Tank, Harrison 9086; Dance Hall Rock, JRM 384; Cottonwood Wash Road, NDA & RA 2765; Paria River, NDA & LCH 3948; Four Mile Bench, SLW & JRM 12402; Nipple Canyon, FWA 262; 14 miles east of Glen Canyon City, RWA 326. San Juan Co., Three Garden, SLW & NDA 11680. Abundant.

Panicum capillare **L.** Witchgrass

Utah: Kane Co., Escalante Canyon, NDA & RA 3210. Rare.

Panicum lanuginosum **Ell.**

Utah: Kane Co., canyon at mile 47, Lake Powell, NDA et al. 3232; Reflection Canyon, SLW & CAT 11852; Escalante Canyon, SLW & GM 11824; do., NDA 4123. San Juan Co., east of confluence of San Juan, NDA & RA 3162; Three Garden, SLW 12438. Local; uncommon.

Panicum obtusum **H.B.K.**

Utah: Hole-in-the-Rock, Harrison 12133. Rare.

Panicum virgatum **L.**

Utah: San Juan Co., east of confluence of San Juan, NDA & RA 3163; Ribbon Canyon, NDA 4104; Three Garden, SLW & CAT 11863. Rare.

Phragmites communis **Trin.**

Utah: Kane Co., Lake Powell, NDA 3136. Widespread; locally common.

Poa bigelovii **Vasey & Scribn.**

Utah: Kane Co., Cockscomb, NDA 4625; San Juan Co., Three Garden, SLW & NDA 11701. Rare.

Poa canbyi **(Scribn.) Piper**

Utah: Kane Co., Kaiparowits Plateau, NDA & DT 5250. Rare.

Poa fendleriana **(Steud.) Vasey**

Utah: Kane Co., Kaiparowits Plateau, Harrison 9041; Cockscomb, NDA 4607; do, NDA 3578; Fifty Mile Spring, JRM 372; Paria Townsite, SLW & NDA 9730; Lake Powell, 2 miles east of Warm Creek, NDA 3720; San Juan Co., Navajo Mt., NDA 4162, 4165; Ribbon Garden, SLW & NDA 11698. Common; widespread.

Poa pratensis **L.** Bluegrass

Utah: Garfield Co., Bryce Canyon, Boyle 1124; 15 miles southwest of Escalante, Hall 13586, 13589. Rare; Introduced lawn and forage grass.

Poa secunda **Presl.**

Utah: Kane Co., Kaiparowits Plateau, Harrison 9052; do, NDA & DT 5255; Cockscomb, NDA 4624. Uncommon.

Polypogon monspeliensis **(L.) Desf.**

Utah: Garfield Co., Escalante, Beck & Tanner s.n.; Kane Co., Willow Tank, Beck & Tanner s.n.; 50 miles south of Escalante, Beck & Tanner s.n.; Hole-in-the-Rock, Harrison 12110; Warm Creek, NDA & RA 2838; Tibbet Spring, NDA & RA 3417; Escalante River, NDA 4224. Common; widespread.

Puccinellia nuttalliana **(Schult.) Hitchc.**

Utah: Garfield Co., Escalante, Stanton; 15 miles southwest of Escalante, Hall 13574. Kane Co., Paradise Canyon, SLW et al. 12594. Uncommon.

Schismus arabicus **Nees.**

Arizona: Coconino Co., Navajo Bridge vicinity, NDA 4560. Uncommon.

Secale cereale **L.** Rye

Utah: Kane Co., 15 miles west of Glen Canyon City, NDA & RA 2878. Introduced weedy species.

Setaria viridis **(L.) Beauv.**

Utah: Kane Co., east of Kanab, NDA 3277. Rare.

Sitanion hystrix **(Nutt.) J. G. Smith**

Arizona: Coconino Co., Cockscomb, NDA 3780. **Utah:** Garfield Co., Bryce Canyon, Boyle 1129; do, Cottam & Hutchings 2751; 15 miles southwest of Escalante, Hall 13605; do, Hall 13594. Kane Co., Willow Tank, Harrison 9083; Cedar Mt., NDA et al. 2750; Cottonwood Wash road, NDA & RA 2766a; Kaiparowits Plateau, NDA & DT 5276; Paria Townsite, JRM 316; Driftwood Canyon, Lake Powell, SLW & NDA

11643; East Clark Bench, Harrison 12072; Four Mile Bench, NDA 4071; Paria River, NDA & LCH 4001; Cedar Mt., NDA & LCH 3828. San Juan Co., Navajo Mt., Gentry & Davidse 1779; do, NDA et al. 2970; Three Garden, SLW & NDA 11692. Common to abundant; widespread.

Sorghastum nutans **(L.) Nash**

Utah: Kane Co., 2 miles north of confluence of San Juan and Colorado canyons, SL & SLW 11880. Rare.

Sorghum halipense **(L.) Pers.** Johnson Grass

Utah: Kane Co., east of Kanab, NDA 3279. Rare.

Sphenopholis obtusata **(Michx.) Scribn.** Wedgegrass

Arizona: Coconino Co., Navajo Creek, NDA 3724. **Utah:** Kane Co., Crosby Canyon, NDA & RA 2890. San Juan Co., Three Garden, SLW & NDA 11670.

Sporobolus airoides **Torr.** Dropseed

Utah: Kane Co., Paria Townsite, JRM 317; Cottonwood Wash road, NDA & RA 2766. Common.

Sporobolus contractus **Hitchc.**

Arizona: Coconino Co., 9.3 miles south of Page, NDA et al. 3350A; Paria Plateau, NDA 6424. **Utah:** Garfield Co., 15 miles southwest of Escalante, Hall 13566. Kane Co., Cottonwood Wash road, NDA & DK 3323; 15 miles west of Glen Canyon City, NDA & RA 2874; Church Wells, NDA & DK 3362. Common.

Sporobolus cryptandrus **(Torr.) Gray**

Utah: Garfield Co., 15 miles southwest of Escalante, Hall 13562, 13563. Kane Co., Cedar Mt., NDA 3112; do, NDA et al. 3249, do, NDA 3130; Four Mile Bench, SLW et al. 12586; Willow Tank, Harrison 9104; do, Beck & Tanner s.n.; Church Wells, NDA & DK 3364; Halls Creek Bay, Lake Powell, SLW & GM 11802; Wahweap Creek, NDA 3485. Common.

Sporobolus flexuosus **(Thurb.) Rydb.**

Arizona: Coconino Co., Paria Plateau NDA, 6416; 9.3 miles south of Page, NDA et al. 3350; Colorado River Canyon north of Navajo Canyon, NDA & RA 3143. **Utah:** Garfield Co., 15 miles southwest of Escalante, Hall 13603. Kane Co., 50 miles south of Escalante, Beck & Tanner s.n.; Cedar Mt., NDA et al. 3248; Dry Rock Creek, Lake Powell, SLW & NDA 11635. San Juan Co., east of confluence of San Juan, NDA et al. 3230. Common.

Sporobolus giganteus **Nash**

Arizona: Coconino Co., 9.3 miles south of Page, NDA et al. 3345. **Utah:** Kane Co., Cedar Mt., NDA 3122; Church Wells, NDA & DK 3368; 6 miles northwest of Page, NDA & RA 3075. Uncommon to rare.

Stipa arida **Jones**

Utah: Kane Co., Kaiparowits Plateau, Harrison 9060; do, NDA & DT 5298. Rare.

Stipa comata **Trin. & Rupr.**

Utah: Kane Co., Hole-in-the-Rock, Harrison 12111; Kaiparowits Plateau, NDA & DT 5256; Cedar Mt., NDA & LCH 3826; Dry Rock Creek, Lake Powell, SLW & NDA 11642; Paria Townsite, JRM 314; Four Mile Bench, SLW & JRM 12403; Paria River, NDA & LCH 3988; Cockscomb, SLW 5337; Last Chance Bay, Lake Powell, SLW & NDA 11602. San Juan Co., Three Garden, SLW & NDA 11666; Navajo Mt., NDA 4198. Common.

Stipa lettermanii **Vasey**

Utah: Garfield Co., 15 miles southwest of Escalante, Hall 13585. San Juan Co., Navajo Mt., NDA 4187. Uncommon.

Stipa neomexicana **(Thurb.) Scribn.**

Utah: Kane Co., Willow Tank, Harrison 9095. Uncommon.

Stipa scribneri **Vasey**

Utah: Garfield Co., 20 miles southeast of Escalante, Holmgren et al. 2050. Kane Co., Little Valley Canyon, NDA et al. 2715. San Juan Co., east of confluence of the San Juan, NDA 4092a. Uncommon.

Stipa speciosa **Trin. & Rupr.**

Utah: Kane Co., Willow Tank, Harrison 9089; Dry Rock Creek, SLW & NDA 11634; Cockscomb, JRM 339. San Juan Co., Piute Canyon, NDA & DT 5349; Rainbow Bridge, SLW & NDA 11653. Common.

Tridens pilosus **(Buckl.) Hitchc.**

Utah: Kane Co., Cockscomb, NDA 4619. Uncommon.

Tridens pulchellus **(HBK) Hitchc.**

Arizona: Coconino Co., Lee's Ferry, Cottam & Hutchings 2602. Kane Co., Willow Tank, Harrison 9085; Nipple Canyon, NDA & RA 2835. Uncommon.

Trisetum spicatum **(L.) Richt.**

Utah: San Juan Co., Navajo Mt., NDA 4164. Rare.

HYDROPHYLLACEAE (Waterleaf Family)

Eucrypta micrantha **Torr.**

Utah: Kane Co., Buckskin Mt., NDA 4648; Cockscomb, NDA 4621; do, NDA 4411. Uncommon.

Nama hispidum **Gray**

Utah: Kane Co., Wahweap Bay, NDA 3549; do, SLW & NDA 9770; Gunsight Bay, SLW & NDA 11584; Warm Creek, NDA 3287. Uncommon.

Nama retrorsum **J. T. Howell**

Utah: Kane Co., Cedar Mt., NDA et al. 3499; do, NDA 3109, Lake Powell, NDA 3694; Paria River, NDA & LCH 3994. Restricted, local, and possibly threatened (Welsh et al., 1975).

Phacelia affinis **Gray**

Utah: Kane Co., Cockscomb, NDA 4617. Rare.

Phacelia cephalotes **Gray**

Arizona: Coconino Co., Cockscomb, NDA 4924. **Utah:** Kane Co., Cockscomb, NDA 4663; do, NDA 4603. Restricted, local, and possibly threatened (Welsh et al., 1975).

Phacelia constancei **Atwood**

Utah: Garfield Co., 39 miles east of Escalante, Reveal & Reveal 2823. Edaphically restricted, local, and threatened (Welsh et al., 1975).

Phacelia corrugata **A. Nels.**

Arizona: Coconino Co., Colorado Canyon, between Lee's Ferry and Glen Canyon Dam, NDA 4589; Glen Canyon Dam, NDA 3450; do, SLW & NDA 9781. **Utah:** Kane Co., Little Valley Canyon, NDA et al. 2723; Brigham Plains, NDA & RA 2789; 15 miles south of Cannonville, NDA & RA 2908; west of Glen Canyon Dam, NDA 3567; Halls Creek Bay, Lake Powell, SLW & GM, 11793; Warm Creek, NDA 3710; East Clark Bench, Harrison 12063; 5 miles southeast of Cannonville, Reveal et al. 797; Grand Bench, NDA 3531; Dry Rock Creek, Lake Powell, SLW & NDA 11617; Gunsight Bay, Lake Powell, SLW & NDA 11587; Wahweap Bay, SLW & NDA 9771; Paria River bridge, SLW & NDA 9744; do, LCH & DA 5374; Crosby Canyon, NDA 3632; Warm Creek, NDA & RA 2842; 15 miles west of Glen Canyon City, NDA & RA 2863. Abundant.

Phacelia crenulata **Torr.**

Arizona: Coconino Co., Lee's Ferry, Larson & Anderson 5993. **Utah:** Kane Co., 10 miles northeast of Glen Canyon City, LCH & NDA 5247; Cedar Mt., NDA 3612, do, RWA 175. Tibbet Canyon, NDA 3603; 14 miles east of Glen Canyon City, RWA 211; Nipple Canyon, RWA 243; 6 miles east of Glen Canyon City, SLW 9791.

Phacelia demissa **Gray var. *demissa***

Utah: Garfield Co., 1 mile east of Henrieville, NDA 1975. Kane Co., 6 miles east of Glen Canyon City, SLW & NDA 9789; Cottonwood Wash road, NDA & RA 2762; 10.5 miles east of Glen Canyon City, NDA 2634; 15 miles west of Glen Canyon City, NDA & RA 2864; 4 miles east of Glen Canyon City, NDA 2630; Warm Creek, NDA & RA 2898; 20 miles south of Escalante, Holmgren et al. 2057; Paria River, NDA & RA 3991; do, SLW 11060; do, NDA 5163. Common.

Phacelia heterophylla **Pursh**

Utah: San Juan Co., Navajo Mt., NDA et al. 2984; do, NDA 4143. Uncommon.

Phacelia howelliana **Atwood**

Utah: San Juan Co., Ribbon Garden, SLW & NDA 11702; Three Garden, SLE & NDA 11675; Piute Canyon, NDA & DT 5346. Uncommon.

Phacelia integrifolia **Torr.**

Arizona: Coconino Co., 4 miles south of Page, RWA 124; do, NDA 2626; Colorado Canyon, between Glen Canyon Dam and Lee's Ferry, NDA & LCH 4027; between Page and Glen Canyon Dam, SLW & NDA 9780; do, NDA 1539. **Utah:** Kane Co., Sit Down Bench, Patton 116; Cedar Mt., NDA 3610; do, NDA et al. 3504; 2 miles west of Glen Canyon City, NDA 3638; do, Nebeker & Skougard 182; do, Cronquist, 10170; Warm Creek, NDA 3709; Northwest of Glen Canyon dam, NDA 1536. Common.

Phacelia ivesiana **Torr.**

Arizona: Coconino Co., Colorado Canyon, between Lee's Ferry and Glen Canyon Dam, NDA 4591. **Utah:** Kane Co., Kaiparowits Plateau, NDA 1867, 1868; East Clark Bench, NDA & RA 2674; Little Valley Canyon, NDA et al. 2727; Cedar Mt., NDA et al. 2746A; do, RWA 231, 48 miles southeast of Escalante, Cronquist 10035; Paria River bridge, SLW & NDA 9758; 57 miles east of Kanab, Cronquist 10152; 25 miles southeast of Escalante, Holmgren et al. 2065a, Ahlstrom Point road, RWA 122. San Juan Co., Three Garden SLW 11896. Common.

Phacelia mammillariensis **Atwood**

Arizona: Coconino Co., 4 miles southeast of Page, RWA 263. **Utah:** Garfield Co., east of Henrieville, NDA 1874. Kane Co., 10 miles northeast of Glen Canyon City, LCH & NDA 5242; Cottonwood Wash, LCH & NDA 5257; 7 miles east of Glen Canyon City, NDA 2632; Warm Creek, Olsen 34; do, NDA 3597. Brigham Plains vicinity, NDA 3743; Gunsight Bay, Lake Powell, SLW & NDA 11582; 3 miles east of Glen Canyon City, NDA 2628; 16 miles east of Glen Canyon City, NDA 4553; 6 miles east of Glen Canyon City, SLW & NDA 9790. Edaphically restricted and endangered (Welsh et al., 1975).

Phacelia rotundifolia **Torr.**

Utah: Kane Co., Cockscomb, NDA 4615 Buckskin Mt., NDA 4652. Uncommon.

Phacelia pulchella **Gray var. *sabulonum* Howell**

Utah: Kane Co., Little Valley Canyon, NDA et al. 2720A; Cottonwood Wash road, NDA & RA 2763a; between Nipple Bench and Lake Powell, Cronquist 10012; Paria River, Cronquist 10201; Warm Creek, NDA & RA 2836; do, NDA & RA 2897; Nipple Canyon, NDA & RA 2827; Nipple Bench, NDA & RA 2809; 18 miles northeast of Glen Canyon City, LCH & NDA 5245. Common.

Phacelia rafaelensis **Atwood**

Arizona: Coconino Co., Navajo Bridge vicinity, NDA & LCH 3814; do, NDA 4563. Restricted, local and possibly threatened (Welsh et al., 1975).

IRIDACEAE (Iris Family)

Iris missouriensis **Nutt.**

Utah: Garfield Co., Bryce Canyon, Boyle 1110. Rare.

Sisyrinchium radicatum **Bicknell**

Utah: Kane Co., Cottonwood Wash, NDA 5356; Four Mile Bench SLW & BW 12439. Rare.

JUNCACEAE (Rush Family)

Juncus arcticus **Willd. var. *balticus* (Willd.) Trautv.**

Utah: Kane Co., southeast of Brigham Plains, NDA & RA 2797; Four Mile Bench, SLW et al. 12580; Reflection Canyon, Lake Powell, SLW & CAT 11849; Escalante Canyon, NDA 4213. San Juan Co., Rainbow Bridge, SLW & NDA 11662; east of confluence of San Juan, NDA 4667. Locally abundant.

Juncus torreyi **Coville**

Utah: Kane Co., Four Mile Bench, SLW et al. 12577; do, NDA 4311; do, SLW et al. 12600. San Juan Co., Three Garden, SLW & CAT 11862; east of confluence of San Juan, NDA 5265. Locally common.

Juncus tracyi **Rydb.**

Utah: Garfield Co., Bryce Canyon, Burkey 156. Kane Co., Escalante Canyon, SLW & GM 11819; do, NDA 4122; Reflection Canyon, SLW & CAT 11850; Cottonwood Wash, Reveal et al. 818. Locally common.

Juncus xiphodes **E. Meyer**

Utah: Garfield Co., Escalante vicinity, Beck s.n., Kane Co., Wahweap Creek, NDA 4344, Four Mile Bench vicinity, SLW 12592, 12599. San Juan Co., east of confluence of San Juan, NDA 4264. Locally common.

JUNCAGINACEAE (Arrowgrass Family)

Triglochin maritima **L.**

Utah: Kane Co., seep, on Four Mile Bench, SLW 12571. Rare.

LABIATAE (Mint Family)

Hedeoma drummondii **Benth.**

Utah: Kane Co., Buckskin Mt., NDA 4659. San Juan Co., east of confluence of San Juan, NDA & RA 3149. This specimen is fragmentary, and it might belong to another species. Rare.

Marrubium valgare **L.**

Utah: Kane Co., east of Kanab, NDA 3282. Rare; introduced weed.

Monardella odoratissima **Benth.**

Utah: San Juan Co., Navajo Mt., Gentry & Davidse 1769; do, NDA et al. 2977. Uncommon.

Poliomintha incana **(Torr.) Gray**

Arizona: Coconino Co., Cedar Mt., NDA et al. 2753; 9 miles south of Page, RWA

229. **Utah:** Garfield Co., Escalante, Cottam 4384; 18 miles southeast of Escalante, Holmgren et al. 2043. Kane Co., Paria River, NDA & LCH 3965; 2 miles west of Glen Canyon City, Nebeker & Skougard 190; do, Cronquist 10172; Cockscomb, JRM 338; Wahweap Creek, Harrison 12091; East Clark Bench, NDA & RA 2675A; do, NDA & RA 3370; Warm Creek, NDA & RA 2843. Locally common.

Salvia dorrii **(Kellogg) Abrams**

Utah: Kane Co., Cedar Mt., NDA et al. 2747; Cockscomb, SLW 5327; Wahweap Creek, Harrison 12090; Nipple Canyon, RWA 242. Uncommon.

LEGUMINOSAE (Legume Family)

Albizia julibrissin **Durazz** Silk Tree

Arizona: Coconino Co., Page (cultivated), NDA et al. 3247.

Astragalus agrestis **Nutt.**

Utah: Garfield Co., Bryce Canyon, Weight s.n. Rare.

Astragalus amphioxys **Gray var.** ***amphioxys***

Arizona: Coconino Co., 4 miles southeast of Page, RWA 237; 5 miles southeast of Page, Nebeker & Skougard 196; 3 miles south of Wahweap Marina, SLW & NDA 9765. **Utah:** Kane Co., 14 miles east of Glen Canyon City, RWA 316; Paria River bridge, SLW & NDA 9757; East Clark Bench, Harrison 12094; Glen Canyon City vicinity, Cronquist 10145; Warm Creek Bay, CAT 173; do, NDA 3707; Wahweap Bay, NDA 3555; Cedar Mt., RWA 177; Cockscomb, SLW 5333. Common.

Astragalus amphioxys **Gray var.** ***vespertinus*** **(Sheld.) Jones**

Arizona: Coconino Co., Buckskin Mt., NDA 4939. **Utah:** Garfield Co., 17 miles west of Escalante, SLW 1704; 0.6 miles north of Escalante, SLW 1702; 3 miles west of Tropic, Reveal et al. 743. Kane Co., 6 miles east of Glen Canyon City, SLW & NDA 9807; Cottonwood Wash road, SLW 5358; Kaiparowits Plateau, Harrison 9058; East Clark Bench, Harrison 12305; between Nipple Bench and Lake Powell, Cronquist 10012; Gunsight Bay, Lake Powell; SLW & NDA 11590; Fifty Mile Spring, JRM 345, 392; Cockscomb, NDA 4632; head of Collets Wash, NDA 306, 307. Paria Townsite, SLW & NDA 9736. Common.

Astragalus ampullarius **Wats.**

Arizona: Coconino Co., Cockscomb, NDA & RA 2880; do, NDA 4923. **Utah:** Kane Co., Cockscomb, NDA 4602; do, 4664. Rare, restricted and threatened (Welsh et al., 1975).

Astragalus argophyllus **Nutt. var.** ***panguicensis*** **(Jones) Jones**

Arizona: Coconino Co., Buckskin Mt., NDA 4938. **Utah:** Garfield Co., Canaan Peak, NDA & DT 5315. Rare.

Astragalus asclepiadoides **Jones**

Utah: Garfield Co., 3 miles southeast of Escalante, Holmgren et al. 2415; do, NDA 5217. Rare.

Astragalus bisulcatus **(Hook.) Gray**

Utah: Garfield Co., 2 miles west of Escalante, Karren 125; do, SLW 1703; Alvey Wash, Death Ridge, NDA 5185; southwest of Cannonville, Reveal et al. 770. Kane Co., head of Alvey Wash, NDA 5211; Kaiparowits Plateau, Harrison 9063; do, NDA & DT 5242; head of Collets Wash, NDA 1872.

Astragalus bryantii **Barneby**

Utah: Kane Co., Glen Canyon (Barneby, 1964). Rare and possibly extinct (Welsh, et al., 1975).

Astragalus ceramicus **Sheld.**

Arizona: Coconino Co., Paria Plateau, LCH & NDA 5202. **Utah:** Garfield Co., 20 miles southeast of Escalante, Holmgren et al. 2046. Kane Co., Kaiparowits Plateau, Harrison 9057; Paria River bridge, SLW & NDA 9749; 12 miles west of Glen Canyon City, Cronquist 10173; East Clark Bench, NDA & RA 2681; Cottonwood Wash road, NDA & RA 2771; 4 miles south of Cannonville, Reveal et al. 785; Cockscomb, SLW 5352. Widespread; uncommon.

Astragalus calycosus **Torr.**

Utah: Garfield Co., Bryce Canyon, 1708. Kane Co., Five Mile Mt., NDA 4646; Four Mile Bench, SLW 12754. Rare.

Astragalus coltonii **Jones var.** ***coltonii***

Utah: Garfield Co., 3 miles northeast of Henrieville, NDA 1248. Kane Co., Kaiparowits Plateau, Harrison 9067; do, NDA 7 dt 5297; Paria Townsite, SLW & NDA 9721,

9733. Utah endemic; locally abundant on the Kaiparowits Plateau.

Astragalus desperatus **Jones var.** ***conspectus*** **Barneby**

Utah: Garfield Co., ca 5 miles southeast of Escalante, SLW 1697; do, Isely et al. 8732; do NDA 5218. Rare and local; threatened (Welsh et al., 1975).

Astragalus desperatus **Jones var.** ***desperatus***

Arizona: Coconino Co., between Page and Glen Canyon Dam, SLW & NDA 9775. **Utah:** Kane Co., Willow Tank, Harrison 9034; do, SLW 1693; Hole-in-the-Rock, Harrison 12145; do, White 120; Lake Powell, Warm Creek Bay, NDA 3704. Locally common.

Astragalus emoryanus **(Rydb.) Cory**

Utah: Kane Co., Cockscomb, NDA 4629 (first Utah record). Rare and endangered (Welsh et al., 1975).

Astragalus episcopus **Wats.**

Utah: Kane Co., Nipple Bench, NDA & RA 2817. Rare.

Astragalus eremiticus **Sheld.**

Arizona: Coconino Co., Buckskin Mt., NDA 4927. **Utah:** Kane Co., Cockscomb, NDA 4630. Rare.

Astragalus flavus **Nutt. var.** ***candicans*** **Gray**

Utah: Kane Co., Nipple Bench, NDA 3477; Cottonwood Wash road, NDA 3576; Cockscomb, NDA 4662; do, NDA 3630; do, Reveal et al. 835; Paria Townsite, Cronquist 10138; do, SLW & NDA 9738. Restricted to seleniferous mud or siltstone.

Astragalus hallii **Gray var. fallax Barneby**

Utah: Kane Co., Buckskin Gulch, SLW 5309; Riggs Creek Canyon, NDA 6130. Rare and local; possibly threatened (Welsh et al., 1975).

Astragalus humistratus **Gray var.** ***humivagans*** **(Rydb.) Barneby**

Utah: Garfield Co., Bryce Canyon, Weight B31/63. Kane Co., east of Grosvenor Arch, NDA 3176; Four Mile Bench, SLW & JRM 12392. Rare.

Astragalus kentrophyta **Gray var.** ***coloradoensis*** **Barneby**

Utah: Kane Co., Wahweap Creek, Harrison 12086; 2 miles west of Glen Canyon City, Cronquist 10164; Paria River, NDA & LCH 3969; Last Chance Bay, Lake Powell, SLW & NDA 11609. Rare and restricted, possibly threatened (Welsh et al., 1975).

Astragalus kentrophyta **Gray var.** ***implexus*** **(Canby) Barneby**

Utah: Garfield Co., Bryce Canyon, Weight s.n. Rare.

Astragalus lancearius **Gray**

Arizona: Coconino Co., Cockscomb, NDA 4927. **Utah:** Kane Co., Buckskin Gulch, SLW 5305; Smoky Mt., NDA 5202; Tibbet Bench, NDA & DT 5068; Cockscomb, NDA s.n.; East Clark Bench, NDA & RA 2674. Rare and local, possibly threatened (Welsh et al., 1975).

Astragalus lentiginosus **Dougl. var.** ***albiflorus*** **(Gray) Schoener**

Utah: Kane Co., east of Glen Canyon City, Webb 63; Cockscomb, SLW 5326; Paria Townsite, Olson 23; Smoky Mt., RWA 131; 6 miles east of Glen Canyon City, SLW & NDA 9808; 31 miles east of Glen Canyon City, NDA et al. 2695; Warm Creek, NDA 3437; Brigham Plains, NDA et al. 3491; 4 miles south of Cannonville, Reveal et al. 783. Common; middle elevations.

Astragalus lentiginosus **Dougl. var.** ***palans*** **(Jones) Jones**

Arizona: Coconino Co., 9.3 miles south of Page, NDA et al. 3341; between Page and Glen Canyon Dam, SLW & NDA 9784. **Utah:** Kane Co., 2 miles east of Glen Canyon City, NDA & DT 3433; Little Valley; NDA 3334; Willow Tank, SLW & NDA 11650; Wahweap Bay, NDA 3695; Paria Townsite, SLW & NDA 9727; Nipple Canyon, RWA 252. San Juan Co., east of confluence of San Juan, NDA & RA 3158; Three Garden, SLW & NDA 11665; Navajo Mt., NDA & DT 5334; Trail Canyon, SLW 11909. Common; lower elevations.

Astragalus lentiginosus **Dougl. var.** ***vitreus*** **Barneby**

Utah: Kane Co., Four Mile Bench, NDA 4073; do, NDA 4064; do, SLW 12413; do, SLW 12426; do. SLW 12446; do, SLW & JRM 12394; Cathy Flat, SLW & NDA s.n.; Nipple Bench, NDA & RA 2820; Brigham Plains, NDA & RA 2791A; Smoky Mt., Cronquist 10022. Locally common, abundant.

Astragalus lonchocarpus **Torr.**

Utah: Garfield Co., Death Ridge vicinity, NDA 5180. Kane Co., 10 miles southeast of Cannonville, SLW 5363; Sheep Creek, Reveal et al. 778; Little Valley, SLW & NDA 116172. Saline sites; common.

***Astragalus malacoides* Barneby**

Utah: Kane Co., Smoky Mt., NDA 5203; Tibbet Spring, NDA 4554; Harris Wash Road, NDA & DT 5300; east of Grosvenor Arch, NDA 5171; Tibbet Bench, NDA & DT 5064; Nipple Bench, NDA 3465; Grand Bench, NDA 3532; Brigham Plains, NDA et al. 3492; Nipple Creek, NDA 3476; Kaiparowits Plateau, JRM 394; do, NDA & DT 5243; Four Mile Bench, SLW 12749. This plant is endemic to the Kaiparowits Region; it is considered as threatened (Welsh et al., 1975).

***Astragalus megacarpus* (Nutt.) Gray**

Utah: Garfield Co., Bryce Canyon, SLW 1707; do, Weight B-31/12. Kane Co., Kaiparowits Plateau, Harrison 9065; Cockscomb, NDA 4637. Rare.

***Astragalus miser* Dougl. var. *oblongifolius* (Rydb.) Cronq.**

Utah: Garfield Co., Canaan Peak, NDA & DT s.n.; do, SLW 12871. Rare.

***Astragalus moencoppensis* Jones**

Utah: Kane Co., Brigham Plains, NDA & RA 2787; Nipple Bench, NDA & RA 2819; between Last Chance and Collett Wash, NDA 5208; Left hand fork of Last Chance Creek, SLW 12748. Uncommon.

***Astragalus mollissimus* Torr. var. *thompsonae* (Wats.) Barneby**

Arizona: Coconino Co., 3 miles south of Wahweap Marina, SLW & NDA 9761. **Utah:** Garfield Co., Escalante, Cottam 4405; 5 miles west of Escalante, SLW 1701; 8 miles southeast of Escalante, Holmgren et al. 2041; 1 mile east of Cannonville, Isely et al. 8739. Kane Co., Willow Tank, Harrison 9108; do, SLW 1691; 10 miles southeast of Cannonville, NDA et al. 3505a; Cottonwood Wash road, SLW 5361; Little Valley Canyon, NDA 3430; Last Chance Bay, SLW & NDA 11603. Abundant.

***Astragalus musiniensis* Jones**

Utah: Garfield Co., vicinity 6 miles southeast of Escalante, SLW 1699; do, Holmgren et al. 22231 do, NDA 5219. Kane Co., Harris Wash road, NDA & DT 5301. Rare.

***Astragalus newberryi* Gray**

Utah: Kane Co., 51 miles south of Escalante, NDA 520; Paria Townsite, SLW 5324; Last Chance Creek, Cronquist 10028; Kaiparowits Plateau, JRM 393a; do, NDA & DT 5248; Wahweap Creek, NDA 3480. Common.

***Astragalus nuttallianus* DC. var. *micranthiformis* Barneby**

Utah: Kane Co., Cockscomb, NDA 3619; Tibbet Canyon, NDA 3443; 6 miles east of Glen Canyon City, SLW & NDA 9804; Paria River, Cronquist 10197. San Juan Co., Three Garden, SLW 11902; confluence of San Juan and Colorado canyons, SLW 11908. Common.

***Astragalus oophorus* Wats. var. *caulescens* Jones**

Arizona: Coconino Co., Buckskin Mt., NDA 4940. **Utah:** Garfield Co., Death Ridge vicinity, NDA 5178. Kane Co., Kaiparowits Plateau, Harrison 9073; do, JRM 395; do, NDA & DT 5237; Four Mile Bench, SLW 12762. Rare.

Astragalus praelongus* Sheld. var. *praelongus

Utah: Garfield Co., 10 miles northeast of Henrieville, Harrison 12104; Pet Hollow, NDA 4327, 4329; 1.5 miles south of Cannonville, Reveal et al. 763; 1 mile east of Cannonville, Isely et al. 8731. Kane Co., Willow Tank, Beck s.n.; do, SLW 1694; Paria Townsite, SLW & NDA 9737; 34 miles southeast of Escalante, Cronquist 10033; Cottonwood Wash, G. Moore 401; 5 miles east of Paria River, JRM 114; Four Mile Bench, SLW & JRM 12393; do, NDA 4074; Wahweap Creek, east of Glen Canyon City, NDA 3464. Common; seleniferous soils.

Astragalus preussii* Gray var. *preussii

Arizona: Coconino Co., Lee's Ferry, LCH 8323. **Utah:** Kane Co., 6 miles east of Glen Canyon City, SLW & NDA 9792; 30 miles east of Glen Canyon City, NDA 4546. Uncommon; seleniferous soils.

***Astragalus sabulonum* Gray**

Arizona: Coconino Co., 4 miles south of Page, NDA 2627a; between Page and Glen Canyon Dam, SLW & NDA 9776; 9 miles south of Page, RWA 216. **Utah:** Kane Co., Labyrinth Canyon, Lake Powell, NDA 3733.

Astragalus sesquiflorus Wats.

Utah: Kane Co., Kaiparowits Plateau, Harrison 9035; do, JRM 391; do, NDA 539; Paria Townsite, Webb 64; Buckskin Gulch, SLW 5307; Wahweap Canyon, NDA 3472; Hackberry Canyon, NDA 3683; Last Chance Creek, NDA 3753. San Juan Co., Navajo Mt., NDA 4192; do, NDA et al. 2975.

Astragalus striatiflorus Jones

Arizona: Coconino Co., Paria River, NDA 4016, NDA 4016; Kane Co., Hackberry Canyon, NDA 3682; Paria River, NDA & LCH 3946. Rare and endangered (Welsh et al., 1975).

Astragalus subcinereus Gray

Utah: Garfield Co., Weight B031/42; do, Cottam & Hutchings 2759; do, Cottam 4366.

Astragalus wardii Gray

Utah: Kane Co., 4 miles south of Cannonville, Reveal et al. 780; do, Cronquist 10215. Endemic to Utah; rare.

Astragalus zionis Jones

Arizona: Coconino Co., Glen Canyon bridge. Moore & Tanner 16. **Utah:** Kane Co., Hackberry Canyon, NDA 3679, 3681; Cedar Mt., NDA 3445; Cockscomb, NDA 3618; Cottonwood Wash road, SLW 5359; do., NDA 3585. San Juan Co., Navajo Mt., NDA 4136, 4167; do, east of confluence of San Juan, NDA & RA 3168. Common on sandstone at lower elevations.

Caragana arborescens **Lam.**

Arizona: Coconino Co., Wahweap campground, cultivated, NDA 3453.

Cercis canadensis **L.**

Arizona: Coconino Co., Wahweap, cultivated, NDA 3454.

Cercis occidentalis **Torr.**

Arizona: Coconino Co., Colorado Canyon, between Lee's Ferry and Glen Canyon dam, NDA 4597. **Utah:** San Juan Co., Rainbow Bridge, NDA & NW 3298; east of confluence of San Juan, NDA & RA 3171, 3193, 3222; Three Garden, SLW & NDA 11683; do, SLW 12423. Unique plants of drainages in sandstone and hanging gardens; uncommon.

Dalea fremontii **Torr.**

Utah: Kane Co., Gunsight Bay, Lake Powell, SLW & NDA 11591; Cottonwood Wash road, Moore 409; Labyrinth Canyon, Lake Powell, NDA 3730; Halls Creek Bay, Lake Powell, SLW & GM 11791; 50 miles south of Escalante, JRM 377; do, Beck & Tanner s.n.; Kaiparowits Plateau, NDA & DT 5296; Hole-in-the-Rock, Harrison 12127; Willow Tank, Harrison 9099. San Juan Co., Three Garden, SLW of San Juan, NDA & RA 3169. Locally common; widespread at lower elevations.

Dalea lanata Spreng.

Arizona: Coconino Co., Kaibito-Tonolea highway, NDA et al. 2913. **Utah:** Kane Co., Cedar Mt., NDA 3123; do, Shaw 1612. Uncommon.

Glycyrrhiza lepidota Pursh

Utah: Garfield Co., Escalante Canyon, Beck 107. Kane Co., Willow Tank, SLW 1690; Paria River, NDA & LCH 4017; Wahweap Cabin, Four Mile Bench, NDA 4345. Local; uncommon.

Hedysarum boreale Nutt. var. ***boreale***

Utah: Garfield Co., Bryce Canyon, Cottam 2758; Escalante, Cottam 4420; Death Ridge vicinity, NDA 5188. Kane Co., Smoky Mt., NDA 5205; Kaiparowits Plateau, NDA & DT 5290. Uncommon.

Lathyrus brachycalyx **Rydb. ssp.** ***zionis*** **(C.L. Hitchc.) Welsh**

Utah: Garfield Co., Bryce Canyon, Harrison 12318. Kane Co., Kaiparowits Plateau, Harrison 9066; do, JRM 379; dom NDA & DT 5283; Cockscomb, NDA 3620; East Clark bench, NDA & RA 2686. Uncommon.

Lathyrus lanzwertii **Kellogg sens. lat.**

Utah: Garfield Co., Death Ridge vicinity, NDA 5187; Escalante Canyon, Cottam 4424. Uncommon.

Lotus longebracteatus **Rydb.**

Utah: Kane Co., Cottonwood Wash, Cronquist 10211; Cockscomb, Harrison 12050; do, SLW 5328; Paria River, NDA & LCH 3958. Uncommon; southwestern portion.

Lotus utahensis **Ottley**

Utah: Garfield Co., Bryce Canyon, Weight B31/66; do, Burkey 166; 15 miles southwest of Escalante, Hall 105. Uncommon.

Lupinus* x *alpestris **A. Nels.**

Utah: Garfield Co., Bryce Canyon, Weight B32/302. Uncommon.

Lupinus caudatus **Kell. var.** ***caudatus***

Utah: Kane Co., Four Mile Bench, SLW & NDA 12375; San Juan Co., Navajo Mt., NDA et al. 2971. Local, in drainages.

Lupinus kingii **Wats.**

Utah: Garfield Co., Bryce Canyon, Weight s.n., June-July 1934. Rare.

Lupinus pusillus **Pursh ssp.** ***intermontanus*** **(Heller) Dunn**

Arizona: Coconino Co., Paria Plateau, NDA & LCH 3775, 3786. **Utah:** Kane Co., East Clark Bench, Harrison 12069; Hole-in-the-Rock, White 116; 50 miles south of Escalante, JRM 346, 373; Cockscomb, SLW 5322; Warm Creek, NDA & RA 2845; Cedar Mt., RWA 173. Common.

Lupinus pusillus **Prush ssp.** ***rubens*** **(Rydb.) Dunn**

Arizona: Coconino Co., 3 miles south of Wahweap Marina, SLW & NDA 9763. **Utah:** Kane Co., Paria River, Cronquist 10176; 48 miles southeast of Escalante, Cronquist 10026; Dry Rock Creek, Lake Powell, SLW & NDA 11627. Common.

Lupinus wyethii **Kellogg**

Utah: Kane Co., Escalante Canyon, SLW & GM 11821. Introduced weed.

Medicago lupulina **L.**

Utah: Kane Co., Escalante Canyon, SLW & GM 11821. Introduced weed.

Medicago sativa **L.**

Utah: Garfield Co., Bryce Canyon, Rowe 178, 1931. Introduced forage plant.

Melilotus alba **Descr.**

Arizona: Coconino Co., Colorado Canyon, between Lee's Ferry and Glen Canyon Dam, NDA & LCH 4033. **Utah:** Kane Co., Four Mile Bench, SLW 12569. Introduced forage plant.

Melilotus officinalis **(L.) Lam.**

Utah: Kane Co., Paria River, NDA & LCH 3961; Escalante River, NDA 4212. Introduced forage plant.

Oxytropis jonesii **Barneby**

Utah: Garfield Co., Bryce Canyon, Cottam 2745; Alvey Wash, 8 miles southeast of Escalante, Holmgren et al. 2022. Edaphically restricted, rare, and threatened (Welsh et al., 1975).

Oxytropis lambertii **Pursh**

Utah: Kane Co., 1 mile east of Paria River, SLW 5353; Cockscomb, NDA 3548; Cottonwood Wash road, NDA & RA 2782; East Clark Bench, NDA & RA 2688. Locally abundant.

Oxytropis oreophila **Gray**

Utah: Garfield Co., Death Ridge, NDA 5186; do, NDA 5215. Rare.

Parryella filifolia **Gray**

Arizona: Coconino Co., Lee's Ferry, Cottam & Hutchings 2600. Rare and possibly threatened.

Petalostemon flavescens **Wats.**

Utah: Kane Co., East Clark Bench, NDA & RA 2675; Cedar Mt., NDA et al. 2735; Little Valley Canyon, NDA et al. 2711; Driftwood Canyon, Lake Powell, SLW & NDA 11646. Common.

Petalostemon occidentale **Torr.**

Utah: Kane Co., Reflection Canyon, Lake Powell, SLW & CAT 11858. San Juan Co., east of confluence of San Juan, NDA 4098; Rainbow Bridge, NDA & NW 3299. Common.

Petalostemon searlsiae **Gray**

Utah: Kane Co., Canaan Peak vicinity, NDA & DT 5312. Local; uncommon.

Peteria thompsonae **Wats.**

Utah: Kane Co., Nipple Bench, NDA & RA 2822; Warm Creek, NDA & RA 2856; Smoky Mt., NDA 5206; Little Valley Canyon, NDA et al. 2723. Locally abundant, especially at middle elevations.

Psoralea epipsila **Barneby**

Utah: Kane Co., west of the Cockscomb, NDA 2668. Rare and endangered (Welsh et al., 1975).

Psoralea juncea **Eastw.**

Utah: Kane Co., Last Chance Bay, Lake Powell, SLW & NDA 11605, East Clark Bench, Harrison 12298; Paria River, NDA & LCH 3943; Cottonwood Wash road, NDA & RA 2775; Cockscomb, SLW 5340. Local; common.

Psoralea lanceolata **Pursh var.** ***lanceolata***

Arizona: Coconino Co., NDA & RA 2884. **Utah:** Garfield Co., Kane Co., 19 miles southeast of Escalante, Holmgren et al. 2044; East Clark Bench, NDA & RA 2691; Cockscomb, CAT 136; Fifty Mile Spring, SLW 1696; between Kodachrome Flat and Cannonville, CAT 143; Brigham Plains, NDA & RA 2788. Common.

Psoralea lanceolata **Pursh var.** ***stenophylla*** **(Rydb.) Toft & Welsh**

Utah: Kane Co., Fifty Mile Spring, HRM

371; Escalante Canyon, SLW & GM 11830; Willow Tank, SLW 1689; 50 miles south of Escalante, Beck & Tanner s.n.; Hole-in-the-Rock, Harrison 12114. Common.

Psorothamnus polyadenius **(Torr.) Rydb.**
Utah: San Juan Co., east of Navajo Mt., NDA & DT 5350. Rare.

Sophora stenophylla **Gray**
Arizona: Coconino Co., Navajo Canyon, NDA 3726. **Utah:** Kane Co., Hole-in-the-Rock, SLW 1695; Harris Wash road, NDA & DT 5205. Uncommon.

Trifolium andinum **Nutt.**
Utah: San Juan Co., Navajo Mt., NDA 4160. Rare.

LILIACEAE (Lily Family)

Agave utahensis **Engelm.**
Arizona: Coconino Co., Paria Canyon, observed but not collected.

Allium acuminatum **Hook.**
Utah: Kane Co., Kaiparowits Plateau, NDA & DT 5246. Rare.

Allium nevadense **Wats.**
Arizona: Coconino Co., Buckskin Mt., NDA 4944; Paria River, Cronquist 10133; 22.5 miles southeast of Cannonville, Reveal & Gentry 812; Five Mile Mt., NDA 4650. Uncommon.

Androstephium breviflorum **Wats.**
Utah: Kane Co., Paria, JRM M110; 14 miles east of Glen Canyon City, RWA 322; Willow Tank, Karren 97; 30 miles east of Glen Canyon City, NDA 4548; East Clark Bench, NDA et al. 3495; Cedar Mt., RWA 172. Widespread; uncommon.

Calochortus aureus **Wats.**
Utah: Kane Co., 28 miles southeast of Escalante, Harrison 9118; Cottonwood Wash road, Moore 408; between Nipple Bench and Lake Powell, Cronquist 10010; Last Chance Creek, NDA 3744; Nipple Bench, NDA & DT 5066; 6 miles east of Glen Canyon City, SLW & NDA 9793. Edaphically restricted; locally abundant.

Calochortus flexuosus **Wats.**
Utah: Kane Co., 40 miles east of Kanab, Cronquist 10140, do, SLW 5343; 16 miles east of Glen Canyon City, NDA 3665; Labyrinth Canyon, Lake Powell, NDA 3729. Low elevations; common.

Calochortus nuttallii **T. & G.**
Utah: Garfield Co., Bryce Canyon, Weight s.n. Kane Co., Paria River, Cronquist 10137; Kaiparowits Plateau, Holmgren et al. 2071; Nipple Bench, NDA & DT 5061; Last Chance Creek, ca 3 miles west of jct. with Escalante Road, NDA 3744. Middle elevations; uncommon.

Eremocrinum albomarginatum **Jones**
Utah: Kane Co., Hole-in-the-Rock, Buss 95. Rare.

Fritillaria atropurpurea **Nutt.**
Utah: Garfield Co., Death Ridge, NDA 5182; Kane Co., Kaiparowits Plateau, Harrison 9043; do, NDA & DT 5232; Hackberry Canyon, NDA 3692. Rare.

Laucocrinum montanum **Nutt.**
Utah: Garfield Co., Bryce Canyon, Weight s.n. Rare.

Smilacina stellata **(L.) Desf.**
Utah: Kane Co., Brigham Plains, NDA & RA 2800. Local; rare.

Yucca angustissima **Engelm.**
Utah: Garfield Co., ca 5 miles southeast of Escalante, NDA 5220. Kane Co., Willow Tank, Harrison 9111; Little Valley Canyon, NDA et al., 2731. Uncommon.

Yucca baccata **Torr.**
Utah: Kane Co., Four Mile Bench, NDA 5175. Middle elevations; uncommon.

Yucca baileyi **W. & S.**
Utah: Kane Co., ¼ mile north of Arizona state line, along U.S. 89, NDA et al. 2733; east of Cockscomb, SLW 5347; southeast of Glen Canyon City, RWA 226; 14 miles east of Glen Canyon City, RWA 312; between Glen Canyon City and Paria River, LCH 4254. Common; sandy sites south central basin.

Yucca harrimaniae **Trel.**
Utah: Garfield Co., Escalante, Cottam 4406. Rare.

Yucca kanabensis **McKelvey**
Utah: Kane Co., Kanab vicinity, SLW 11065. Rare.

Yucca toftiae **Welsh**
Utah: Kane Co., Dry Rock Creek, Lake Powell, SLW & GM 11779. San Juan Co., Ribbon Garden, NDA 4112; Three Garden, SLW 11935a. Endemic, local, and possibly threatened (Welsh et al. 1975).

Zigadenus paniculatus **Nutt.**

Utah: Kane Co., Buckskin Gulch, SLW 5322; Kaiparowits Plateau, NDA & DT 5275. Rare.

Zigadenus vaginatus **(Rydb.) Macbr.**

Utah: Kane Co., Reflection Canyon, SL & SLW 11878. San Juan Co., east of confluence of San Juan, NDA & RA 3180; do, NDA et al. 3229. Endemic, local, and possibly endangered (Welsh et al. 1975).

LINACEAE (Flax Family)

Linum aristatum **Engelm.**

Utah: Kane Co., Willow Tank, Harrison 9097; Paria River, NDA & LCH 3954. Widespread; uncommon.

Linum kingii **Wats.**

Utah: Garfield Co., Bryce Canyon, Cottam 2749. Uncommon.

Linum perenne **L.**

Utah: Garfield Co., Bryce Canyon, Weight s.n. Kane Co., Cottonwood Wash road, NDA & LCH 3834; Kaiparowits Plateau, NDA & DT 5280. Widespread; uncommon.

Linum puberulum **(Engelm.) Heller**

Utah: Garfield Co., 1.5 miles south of Cannonville, Reveal et al. 764. Rare.

Linum subteres **(Trel.) Winkler**

Utah: Kane Co., Kodachrome Flat, Holmgren & Holmgren 4711; 15 miles west of Glen Canyon City, NDA & RA 2871; East Clark Bench, NDA & RA 2690; Four Mile Bench, SLW & JRM 12410. Rare.

LOASACEAE (Loasa Family)

Mentzelia albicaulis **(Dougl.) T. & G.**

Utah: Garfield Co., 1.3 miles south of Cannonville, Revel et al. 759. Kane Co., Kaiparowits Plateau, Harrison 9074, do, NDA & DT 5289; Little Valley, NDA 3516; 6 miles east of Glen Canyon City, SLW & NDA 9805; Warm Creek, NDA 3718; Cockscomb, SLW 5339; Cedar Mt., RWA 188. Common.

Mentzelia integra **(Jones) Tidestr.**

Utah: San Juan Co., Three Garden, SLW 12418. Rare.

Mentzelia multiflora **(Nutt.) Gray**

Arizona: Coconino Co., Colorado Canyon, between Glen Canyon Dam and Lee's Ferry, NDA & LCH 4036. 9 miles south of Page, NDA et al. 338. Utah: Kane Co., 31.5 miles east of Glen Canyon City, NDA et al. 2706, 20 miles southeast of Escalante, Buss 85; Nipple Canyon, NDA & RA 2834; 15 miles west of Glen Canyon City, NDA & RA 2877; Smoky Mt., NDA & NW 3292; Gunsight Bay, Lake Powell, SLW & NDA 11580; Hole-in-the-Rock, Harrison 12147; Willow Tank, Harrison 9027; Cottonwood Wash road, Reveal et al. 829. San Juan Co., east of confluence of San Juan, NDA & RA 3166. Common.

LOBELIACEAE (Lobelia Family)

Lobelia cardinalis **L.**

Utah: Kane Co., Reflection Canyon, SL & SLW 11879; Escalante Canyon, NDA & RA 3204. San Juan Co., Rainbow Bridge, NDA & NW 3301; east from confluence of San Juan, NDA & RA 3170A, 3192; do, NDA et al. 3228. Hanging gardens; uncommon.

MALVACEAE (Mallow Family)

Sphaeralcea coccinea **(Pursh) Rydb.**

Arizona: Coconino Co., Colorado Canyon, between Glen Canyon Dam and Lee's Ferry, NDA & LCH 4037. Utah: Garfield Co., Bryce Canyon, Bosworth 24; Escalante Canyon, Cottam 4372. Kane Co., Last Chance Creek, NDA 3751. Common.

Sphaeralcea grossulariaefolia **(H. & A.) Rydb.**

Arizona: Coconino Co., NDA 3727; Page vicinity, SLW & NDA 9785; 9.3 miles south of Page, NDA et al. 3344. Utah: Kane Co., Nipple Canyon, RWA 250; Cedar Mt., RWA 347; Hole-in-the-Rock, Harrison 12112; Little Valley Canyon, NDA et al. 2725; Willow Tank, Harrison 9032; Cottonwood Wash road, NDA & RA 2764; Grand Bench, NDA 4256, 2 June 1972; Paria River, NDA & LCH 3956; Last Chance Bay, Lake Powell, SLW & NDA 11597; Escalante Canyon, NDA & RA 3211; do, SLW & GM, 11827; 1 mile west of Glen Canyon City, Toft & Jefferies 123; mouth of Escalante Canyon, Lake Powell, SLW & GM 11810. San Juan Co., canyon bottom 1 mile east of Hole-in-the-Rock, SLW & CAT

11869; Three Garden, SLW 12420. Abundant.

Sphaeralcea leptophylla **(Gray) Rydb.**

Arizona: Coconino Co., Cottam 2624; 2 miles north of Glen Canyon Dam, LCH 1005. Rare.

Sphaeralcea parvifolia **A. Nels.**

Arizona: Coconino Co., Colorado Canyon, between Glen Canyon Dam and Lee's Ferry, NDA & LCH 4038. **Utah:** Garfield Co., Escalante, Cottam 4371; do, Beck & Tanner 8240; do, Jefferies 38; Fifty Mile Spring, JRM 354; Cedar Mt., RWA 189; Gunsight Bay, Lake Powell, SLW & NDA 11593; Dry Rock Creek, Lake Powell, SLW & NDA 11625; Cockscomb, NDA 4605; Glen Canyon City vicinity, Cronquist 10149; Four Mile Bench, SLW & JRM 12396; Grosvenor Arch, Jefferies 44. Abundant.

NYCTAGINACEAE (Four-O'Clock Family)

Abronia fragrans **Nutt.**

Arizona: Coconino Co., Page vicinity, SLW & NDA 9783. **Utah:** Kane Co., Beck s.n.; Kaiparowits Plateau, NDA & DT 5229; Cedar Mt., RWA 186; Cockscomb, NDA 3582, Cottonwood Wash road, Reveal et al. 811; Willow Tank, White 90; Hole-in-the-Rock; White 126; Glen Canyon City vicinity, Cronquist 10160; 34 miles southeast of Escalante, Cronquist 10032; 8 miles south of Paria Townsite, Harrison 12058; East Clark Bench, Harrison 12065; Warm Creek, NDA & RA 2844; Gunsight Bay, Lake Powell, SLW & NDA 11601. Abundant.

Abronia nana **Wats.**

Utah: Garfield Co., Bryce Canyon, Cottam 4359. Kane Co., Cathy Flat, SLW & NDA 11716; Five Mile Mt., NDA 4643; Cockscomb, NDA 3623; Alvey Wash, NDA 5213; 4 miles south of Cannonville, Reveal et al. 784; Four Mile Bench, NDA 5174; Last Chance Creek, NDA 3750; Buckskin Gulch, SLW 5308. Local; uncommon.

Allionia choisyi **Standl.**

Arizona: Coconino Co., 8 miles southeast of Page, NDA et al. 3244. Rare.

Allionia incarnata **L.**

Arizona: Coconino Co., Lee's Ferry, Cottam 2621. **Utah:** Kane Co., east of Twilight Canyon, Lake Powell, NDA & RA 3147. Uncommon.

Boerhaavia torreyana **(Wats.) Standl.**

Utah: Kane Co., Cedar Mt., NDA & DK 3389. Rare.

Hermidium alipes **Wats.**

Utah: Kane Co., 6 miles east of Warm Creek, SLW & NDA 9788; Cottonwood Wash road, SLW 5355; between Nipple Bench and Lake Powell, Cronquist 10014; 30 miles east of Glen Canyon City, NDA 4550. Edaphically restricted; uncommon.

Mirabilis multiflora **(Torr.) Gray**

Utah: Kane Co., Kaiparowits Plateau, NDA & DT 5295; Nipple Bench, NDA & RA 2818A; Warm Creek, NDA & RA 2855; Escalante Canyon, NDA 4114; Four Mile Bench, SLW 12831. Widespread; locally common.

Oxybaphus glaber **Wats.**

Utah: San Juan Co., NDA & RA 3153. Rare.

Oxybaphus linearis **(Pursh) Robins.**

Utah: Kane Co., Cottonwood Wash road, NDA & RA 2763; Cockscomb, NDA 2923. Uncommon.

Tripterocalyx micranthus **(Torr.) Hook.**

Arizona: Coconino Co., Lee's Ferry, Cottam 2606. **Utah:** Kane Co., Willow Tank, Beck & Tanner s.n.; Cedar Mt., RWA 329; Warm Creek, NDA & RA 2848; Paria River, NDA & LCH 3973; East Clark Bench, NDA & RA 2680. San Juan Co., Three Garden, SLW & NDA 11676. Uncommon.

Tripterocalyx wootonii **Standl.**

Arizona: Coconino Co., Cedar Mt., NDA et al. 2751. **Utah:** Kane Co., Willow Tank, Harrison 9026; Hole-in-the-Rock, Harrison 12105; 50 miles south of Escalante, Beck & Tanner s.n.; Cedar Mt., NDA & LCH 3818; Lake Powell east of Wahweap Marina, NDA 3697; Glen Canyon City vicinity Cronquist 10143; Paria River, Cronquist 10178. Locally common.

OLEACEAE (Olive Family)

Fraxinus anomala **Torr.**

Arizona: Coconino Co., Colorado River between Glen Canyon Dam and Lee's Ferry, NDA 4598. **Utah:** Garfield Co., Escalante, Cottam 4401; 1.3 miles south of Cannonville, Reveal 758. Kane Co., Wahweap Creek, NDA 3458; Cedar Mt., RWA 185;

Fifty Mile Spring, JRM 376; Paria Townsite, SLW & NDA 9741; 20 miles south of Cannonville, Christensen s.n.; Smoky Mt., Cronquist 10024; Hole-in-the-Rock, White 131, Cockscomb, SLW 5335. Widespread; uncommon.

Menodora scabra Gray
Utah: Garfield Co., Holmgren et al. 2033. Rare and possibly threatened (Welsh et al. 1975).

ONAGRACEAE (Evening-Primrose Family)

***Epilobium angustifolium* L.**
Utah: San Juan Co., Navajo Mt., NDA et al. 2976. Rare.

***Epilobium hornemannii* Reichenb.**
Utah: Kane Co., Warm Creek, NDA & RA 2824. Uncommon; wet sites.

Gaura parviflora Dougl.
Utah: Kane Co., east of Kanab, NDA 3278. Rare.

***Gayophytum nuttallii* T. & G.**
Utah: San Juan Co., Navajo Mt., NDA 4178; do, NDA & DT 5341. Uncommon.

Oenothera albicaulis Pursh
Arizona: Coconino Co., Paria Plateau, NDA & LCH 3762. **Utah:** Garfield Co., 1.5 miles south of Cannonville, Reveal 765; Kane Co., Smoky Mt., NDA 3746; 6.6 miles southeast of Cannonville, Reveal et al. 799; Hole-in-the-Rock, White 93; 6 miles east of Paria, Harrison 12317; East Clark Bench, Harrison 12081; Paria, JRM 116. Common.

***Oenothera caespitosa* Nutt. var. *jonesii* Munz**
Utah: Kane Co., Kaiparowits Plateau, NDA & DT 5269; 6.6 miles south of Cannonville, Reveal 798, no date. Uncommon.

***Oenothera caespitosa* Nutt. var. *marginata* (Nutt.) Munz**
Utah: Kane Co., Fifty Mile Spring, JRM 360; Dry Rock Creek, SLW & NDA 11619; 15 miles west of Glen Canyon City, NDA & RA 2868; between Nipple Bench and Lake Powell, Cronquist 10011; Paria Townsite, SLW & NDA 9739; 6 miles east of Glen Canyon City, SLW & NDA 9797; Warm Creek, NDA & RA 2841; Cottonwood Wash road, LCH & NDA 5251; Cedar Mt., NDA 3107. San Juan Co., Navajo Mt., NDA 4193. Common.

Oenothera brachycarpa Gray
Utah: Garfield Co., 8 miles southeast of Escalante, Holmgren 2027; Bryce Canyon, Cottam 2747. Rare.

Oenothera chamaenerioides Gray
Utah: Kane Co., Paria River, Cronquist 10198; Cockscomb, NDA 4622. Rare.

***Oenothera contorta* Dougl. ex Hook.**
Utah: Kane Co., Cedar Mt., NDA 4666; Butler Valley, NDA 5166; Kaiparowits Plateau, NDA & DT 5226. Uncommon.

***Oenothera coronopifolia* T. & G.**
Utah: Garfield Co., Bryce Canyon, Boyle 1162. Rare.

***Oenothera decorticans* (H. & A.) Greene**
Utah: Kane Co., Labyrinth Canyon, Lake Powell, NDA 3734; Grand Bench, NDA 3525; 6 miles east of Warm Creek, SLW & NDA 9796; Dry Rock Creek, Lake Powell, SLW & NDA 11632. Local; uncommon.

***Oenothera eastwoodiae* (Munz) Raven**
Utah: Kane Co., Little Valley Canyon, NDA et al. 2761A; 6 miles east of Glen Canyon City, SLW & NDA 9787; 17 miles east northeast of Glen Canyon City, RWA 204; Warm Creek, RWA 115; Cottonwood Wash road, NDA & RA 2760; Sit Down Bench, Patton 126. Local; common to abundant.

***Oenothera flava* (A. Nels.) Garrett**
Utah: Kane Co., Paria, JRM 117. Rare.

***Oenothera lavandulaefolia* T. & G.**
Utah: Garfield Co., Bryce Canyon, Cottam 2748. Kane Co., Drip Point, NDA 4066; Four Mile Bench, SLW & JRM 12408a. Local; common.

Oenothera longissima Rydb.
Utah: Kane Co., Wahweap seep, west of Four-Mile Bench, NDA 4343, Escalante Canyon, SLW & GM 11809. San Juan Co., east of confluence of San Juan, NDA & RA 3156; Navajo Mt., NDA et al. 2986. Common; drainages.

Oenothera megalantha Munz
Utah: Kane Co., Smoky Mt., NDA 5952, 6008. New Utah record; rare and possibly endangered (Welsh et al. 1975).

Oenothera multijuga Wats.
Utah: Kane Co., Paria River, Woodruff 1121; 14 miles east of Glen Canyon City, NDA & RA 2895A. Uncommon.

***Oenothera pallida* Lindl.**

Arizona: Coconino Co., east side Glen Canyon Dam, NDA 3448; Colorado River between Glen Canyon Dam and Lee's Ferry, NDA & LCH 4022. **Utah:** Garfield Co., Bryce Canyon, Cottam 4355. Kane Co., Fifty Mile Spring, JRM 344; 25 miles south of Cannonville, SLW 5360; Church Wells, JRM 331; Harris Wash road, NDA & DT 5307; Paria River bridge, SLW & NDA 9751; Warm Creek, NDA & RA 2840; 14 miles east of Glen Canyon City, RWA 315; 2 miles west of Glen Canyon City, Nebeker & Skougard 181; East Clark Bench, Harrison 12084; Willow Tank, Harrison 9093; Cockscomb, JRM 333. San Juan Co., Three Garden, SLW 12421. Abundant.

***Oenothera pterosperma* Wats.**

Arizona: Coconino Co., Buckskin Mt., NDA 4430. **Utah:** Kane Co., Cockscomb, NDA 4622a. Uncommon.

Oenothera scapoidea* T. & G. var. *scapoidea

Utah: Kane Co., Cottonwood Wash road, NDA 5161. Rare.

***Oenothera walkeri* (A. Nels.) Raven**

Arizona: Coconino Co., Lee's Ferry, Cottam 2631. **Utah:** Kane Co., Labyrinth Canyon, Lake Powell, NDA 3741; Nipple Bench, NDA & DT 5058; Gunsight Bay, Lake Powell, SLW & NDA 11578; Little Valley Canyon, NDA et al. 2726; Warm Creek, NDA & RA 2905; Colorado Canyon between Glen Canyon Dam and Lee's Ferry, NDA & LCH 4025; Paria River LCH & NDA 5386; Dry Rock Creek, Lake Powell, SLW & NDA 11639. Local; common.

ORCHIDACEAE (Orchid Family)

***Corallorhiza maculata* Raf.?**

Utah: San Juan Co., Navajo Mt., NDA 4170. Rare.

***Epipactis gigantea* Dougl.**

Arizona: Coconino Co., Navajo Creek, NDA & RA 3220; Paria Canyon, Woodruff 1128. **Utah:** Kane Co., Brigham Plains, ND & RA 2792; Four Mile Bench, SLW & BW 12445; do, SLW 12573; Escalante Canyon, NDA & RA 3218; Little Valley Canyon, NDA et al. 2713; Hole-in-the-Rock, Harrison 12117; Dry Rock Creek, Lake Powell, SLW & NDA 11640. San Juan Co., Three Garden, SLW 12424. Hanging gardens; common.

***Habenaria sparsiflora* Wats. var. *laxiflora* (Rydb.) Correll**

Utah: Kane Co., Four Mile Bench, SLW 12577; do, SLW & BW 12444. Rare.

OROBANCHACEAE (Broomrape Family)

Orobanche fasciculata* Nutt. var. *fasciculata

Arizona: Coconino Co., 9.3 miles south of Page, NDA & LCH 4018; 4 miles south of Page, NDA 2627. Rare.

***Orobanche fasciculata* Nutt. var. *lutea* (Parry) Achey**

Utah: San Juan Co., Gardens Cove, confluence of the San Juan, SLW 11932. Rare.

***Orobanche multiflora* Nutt.**

Utah: Kane Co., Pool Garden, CAT 168. San Juan Co., Gardens Cove, confluence of the San Juan, SLW 11931. Rare.

PAPAVERACEAE (Poppy Family)

***Argemone corymbosa* Greene ssp. *arenicola* G. B. Ownbey**

Utah: Kane Co., 16 miles east of Glen Canyon City, NDA 3664. Common.

***Argemone munita* Dur. & Hilg. ssp. *rotundata* (Rydb.) Ownbey**

Arizona: Coconino Co., Cockscomb, NDA & RA 2886; Kaiparowits Plateau, NDA & DT 5268. Uncommon.

PINACEAE (Pine Family)

***Abies concolor* (Gard. & Glend.) Hoopes**

Utah: Garfield Co., Canaan Peak, abundant, not collected. Locally abundant.

***Abies lasiocarpa* (Hook) Nutt.**

Utah: San Juan Co., Navajo Mt., NDA et al. 2987; do, NDA & SK 3404. Locally abundant.

***Picea engelmannii* Parry**

Utah: San Juan Co., NDA & DK 3406. Locally abundant.

***Picea pungens* Engelm.**

Utah: Bryce Canyon, Buchanan 133 (Bryce). Uncommon.

Pinus edulis **Engelm.**

Utah: Garfield Co., Bryce Canyon, Cottam 4364. Kane Co., Four Mile Bench, SL & ERW 12369. San Juan Co., Navajo Mt., NDA et al. 3005. Middle elevations; abundant.

Pinus flexilis **James**

Utah: Garfield Co., Bryce Canyon, Harrison. San Juan Co., NDA & DK 3405. High elevations; uncommon.

Pinus longaeva **D. K. Bailey**

Utah: Garfield Co., Bryce Canyon, Cottam 4365. Restricted, and possibly threatened (Welsh et al. 1975).

Pinus ponderosa **Laws.**

Utah: Kane Co., Hackberry Canyon, NDA 3691. San Juan Co., Navajo Mt., NDA et al. 2992. Widespread; only locally common to abundant.

Pseudotsuga menziesii **(Mirb.) Franco**

Utah: Garfield Co., 10 miles northeast of Henrieville, Harrison 12103. Kane Co., Death Ridge vicinity, SLW 12764. Middle and higher elevations; locally abundant.

PLANTAGINACEAE (Plantain Family)

Plantago purshii **R. & S.**

Arizona: Coconino Co., 4 miles southeast of Page, RWA 348. **Utah:** Garfield Co., southeast of Escalante, Holmgren et al. 2039. Kane Co., Cedar Mt., NDA & LCH 3823; Fifty Mile Spring, JRM 352; East Clark Bench, Harrison 12082; Paria River, NDA & LCH 3987; Labyrinth Canyon, NDA 3739. San Juan Co., Ribbon Garden, NDA 4108. Abundant.

POLEMONIACEAE (Phlox Family)

Eriastrum diffusum **(Gray) Mason**

Utah: Kane Co., Kaiparowits Plateau, Harrison 9075; Cedar Mt., NDA & LCH 3819. Uncommon.

Gilia aggregata **(Pursh) Spreng.**

Utah: Garfield Co., Bryce Canyon, Boyle 1115; Escalante, Cottam 4393. Kane Co., Four Mile Bench, NDA 4079; do, SLW et al. 12573; Hole-in-the-Rock, Karren 106; 25 miles southeast of Escalante, Holmgren et al. 2069; Buckskin Gulch, SLW 5311; Escalante Canyon, NDA & RA 3207; Collett Canyon, Woodruff 1157. San Juan Co., Rainbow Bridge, SLW & NDA 11663. Common.

Gilia congesta **Hook.**

Arizona: Coconino Co., Cockscomb, NDA 3059. **Utah:** Garfield Co., Pet Hollow, NDA 4331; Hackberry Canyon, NDA & RA 2806. Uncommon.

Gilia gunnisonii **T. & G.**

Arizona: Coconino Co., Lee's Ferry, Cottam 2601; do, NDA 4580; 4 miles southeast of Page, RWA 239; 8 miles south of Page, RWA 225. **Utah:** Kane Co., East Clark Bench, Harrison 12076; Fifty Mile Spring, JRM 355; Willow Tank, Harrison 9102; Hole-in-the-Rock, White 114; Cedar Mt., NDA 3124; Paria River, NDA & LCH 4006; Warm Creek, NDA 3713; Wahweap Bay, NDA 3550; Tibbet Canyon, NDA 3604; Nipple Bench, NDA & RA 2814; 14 miles east of Glen Canyon City, RWA 319. Common.

Gilia hutchinsifolia **Rydb.**

Arizona: Coconino Co., Lee's Ferry, Cottam 2605; Page vicinity, SLW & NDA 9775. **Utah:** Kane Co., Gunsight Bay, SLW & NDA 11577. Uncommon.

Gilia latifolia **Wats.**

Utah: Kane Co., Warm Creek, NDA & RA 2854; do, NDA & RA 2901; Nipple Creek, NDA & RA 2829; Tibbet Canyon, NDA 5959. Rare and local; possibly threatened (Welsh et al. 1975).

Gilia leptomeria **Gray**

Arizona: Coconino Co., Lee's Ferry, NDA 4575, Paria Plateau, NDA & LCH 3782. **Utah:** Kane Co., Kaiparowits Plateau, Harrison 9076A; do, NDA & DT 5244; 30 miles east of Glen Canyon City, NDA 4547; Cedar Mt., NDA et al. 2744; Willow Tank, Harrison 9109; 25 miles southeast of Escalante, Holmgren 2066; 6 miles east of Glen Canyon City, SLW & NDA 9794; Cockscomb, NDA 3595; Nipple Bench, NDA & DT 5065; Paria River, Cronquist 10135; Warm Creek, NDA & RA 2902; 8 miles southeast of Cannonville, Reveal 803; west of Glen Canyon City, Cronquist 10154. Common.

Gilia longiflora **(Torr.) G. Don**

Arizona: Coconino Co., Cockscomb, NDA 3053; Paria Plateau, NDA & GM 4291.

Utah: Kane Co., Cedar Mt., RWA 174; East Clark Bench, Harrison 12073. Uncommon.

Gilia micromeria **Gray**

Arizona: Coconino Co., Buckskin Mt., NDA 4931. **Utah:** Kane Co., NDA & DT 5062. Rare.

Gilia opthalmoides **Brand**

Utah: Kane Co., Fifty Mile Spring, JRM 356; Kaiparowits Plateau, Harrison 9076; Nipple Canyon NDA & RA 2830; 25 miles southeast of Escalante, Holmgren et al. 2067. San Juan Co., SLW & NDA 11704. Uncommon.

Gilia polycladon **Torr.**

Arizona: Coconino Co., Lee's Ferry, Snow 2; do, NDA 4579. **Utah:** Kane Co., 22 miles southeast of Escalante, Holmgren et al. 2056; Sit Down Bench, Olson 39; Fifty Mile Spring, JRM 357; Nipple Canyon, NDA & RA 2834A; Paria River NDA & LCH 3986; Little Valley, NDA 3519; Tibbet Canyon, NDA 3607. Low elevations; common.

Gilia subnuda **Torr.**

Arizona: Coconino Co., Paria Canyon, Woodruff 1125. **Utah:** Garfield Co., Escalante, Cottam 4389; 20 miles southeast of Escalante, Holmgren et al. 2047; 1.3 miles south of Cannonville, Reveal et al. 753. Kane Co., Harris Wash road, NDA & DT 5306; Cottonwood Wash Road, SLW 5356; Buckskin Gulch, SLW 5321; Four Mile Bench, SLW 12428; Hackberry Canyon, NDA 3680. Common; widespread.

Langloisia setosissima **(T. & G.) Greene**

Utah: Kane Co., 20 miles east of Glen Canyon City, NDA & DT 5072. Low elevations; uncommon.

Leptodactylon pungens **(Torr.) Nutt.**

Arizona: Coconino Co., Paria Plateau, NDA & LCH 3789. Rare.

Leptodactylon watsonii **(Gray) Rydb.**

Utah: Kane Co., Flat Top, NDA et al. 2961. Rare.

Linanthus bigelovii **(Gray) Greene**

Utah: Kane Co., Cockscomb, NDA 4616. Rare.

Linanthastrum nuttallii **(Gray) Ewan**

Utah: Bryce Canyon, Coltam 4399. Rare.

Microsteris gracilis **(Dougl.) Greene**

Arizona: Coconino Co., Buckskin Mt., NDA 4935. **Utah:** San Juan Co., Navajo Mt., NDA & DT 5342. Uncommon.

Navarretia breweri **(Gray) Greene**

Utah: San Juan Co., Navajo Mt., NDA 4175; do, NDA & DT 5336. Uncommon.

Phlox austromontana **Coville**

Utah: Kane Co., Cockscomb, NDA 4610. Rare.

Phlox cluteana **A. Nels.**

Utah: San Juan Co., Navajo Mt., NDA 4148. Rare and possibly threatened (Welsh et al. 1975).

Phlox hoodii **Richards.**

Utah: Garfield Co., Bryce Canyon, Weight s.n.; Escalante, Cottam 4423. Kane Co., Four Mile Bench, NDA 3487; 20 miles south of Cannonville, Christensen s.n.; Round Valley, NDA 3467; Kaiparowits Plateau, Harrison 9071; 4 miles south of Cannonville, Cronquist 10083; Fifty Mile Spring, JRM 370. Widespread; common.

Phlox longifolia **Nutt.**

Utah: Kane Co., Buckskin Gulch, SLW 5316; Cockscomb, NDA 3616; Four Mile Bench, NDA 3758. Widespread; uncommon.

Phlox stansburyi **(Torr.) Heller.**

Utah: Kane Co., Kaiparowits Plateau, Harrison 9048; do, NDA & DT 5285; 8 miles south of Paria, Harrison 12054; Paria Townsite, SLW & NDA 9735; 29 miles south of Cannonville, Christensen s.n. San Juan Co., Navajo Mt., NDA et al. 2996. Widespread; uncommon.

Polemonium delicatum **Rydb.**

Utah: San Juan Co., Navajo Mt., NDA 4154. Rare.

Polemonium viscosum **Nutt.**

Utah: Garfield Co., Bryce Canyon, Cottam 2783. Rare.

POLYGALACEAE (Milkwort Family)

Polygala subspinosa **Wats.**

Utah: Kane Co., Four Mile Bench, SLW 12788. Widespread; uncommon.

POLYGONACEAE (Buckwheat Family)

Chorizanthe brevicornu **Torr.**

Utah: Kane Co., Escalante Canyon, SLW & GM 11804. Rare.

Chorizanthe thurberi **(Gray) Wats.**

Utah: Kane Co., left hand fork of Last Chance Canyon, ca 10 miles east of Four Mile Bench, SL & ERW 12721. Rare.

Eriogonum alatum **Torr. var.** ***alatum***

Arizona: Coconino Co., Paria Plateau, NDA & GM 4294; do, NDA 3060. **Utah:** Garfield Co., Escalante, Cottam 4398. Kane Co., 25 miles southeast of Escalante, Holmgren et al. 2070; Four Mile Bench, SLW 12431. Widespread; uncommon.

Eriogonum cernuum **Nutt.**

Arizona: Coconino Co., Cockscomb, NDA & DK 3388; do, NDA 3069; Colorado Canyon between Lee's Ferry and Glen Canyon Dam, NDA 4582. **Utah:** Garfield Co., Pet Hollow, NDA 4341; Cedar Mt., NDA 4057; Nipple Bench, NDA & RA 2813. Common.

Eriogonum corymbosum **Benth. var.** ***corymbosum***

Utah: Garfield Co., Pet Hollow, NDA 4336; Kane Co., Smoky Mt., NDA & NW 3294; 15 miles southeast of Cannonville, SL & SLW 9414; Buckskin Gulch, SL & SLW 9422; Four Mile Bench, NDA 4301. Common.

Eriogonum corymbosum **Benth. var.** ***glutinosum*** **Jones**

Arizona: Coconino Co., Lee's Ferry, NDA 4353. **Utah:** Garfield Co., 20 miles southwest of Escalante, Holmgren et al. 2413; 12 miles northeast of Henrieville, Reveal & Reveal 2887; 4 miles east of Henrieville, NDA 4347; Tibbet Canyon, NDA & DK 3325; 6 miles east of Glen Canyon City, NDA & DK 3353. Low elevations; common.

Eriogonum corymbosum **Benth. var.** ***orbiculatum*** **(Stokes) Reveal & Brotherson**

Utah: Garfield Co., 50 miles southeast of Escalante, Beck s.n. Sandstone basins, Canyon of the Colorado; uncommon.

Eriogonum deflexum **Torr. var.** ***deflexum***

Utah: Garfield Co., 7.5 miles southeast of Escalante, Holmgren et al. 2414. Kane Co., Tibbet Canyon, NDA & DK 3333; Nipple Canyon, NDA & RA 2832; Warm Creek, NDA & RA 2900; Buckskin Wash, SC & SLW 9420; Paria River, SLW 5354. Common.

Eriogonum flexum **Jones**

Utah: Garfield Co., 20 miles southeast of Escalante, Holmgren et al. 2045; Kane Co., Cottonwood Wash road, Reveal et al. 825; Paria River, Cronquist 10130; Nipple Canyon, NDA & RA 2828; Nipple Bench, NDA & DT 5069. Common.

Eriogonum gordonii **Benth.**

Utah: Cottonwood Wash road, NDA & RA 2755; do, Reveal et al. 824. Common.

Eriogonum heermannii **Dur. & Hilg. var.** ***subracemosum*** **(Stokes) Reveal**

Arizona: Coconino Co., Navajo Mt. road, NDA & DK 3391. Uncommon.

Eriogonum hookeri **Wats.**

Utah: Kane Co., head of Alvey Wash, NDA 5209. Uncommon.

Eriogonum inflatum **Torr. & Frem. var.** ***inflatum***

Arizona: Coconino Co., Colorado Canyon, between Glen Canyon Dam and Lee's Ferry, NDA & LCH 4026. **Utah:** Kane Co., Willow Tank, Beck & Tanner s.n.; Paria River, NDA & LCH 3951; Warm Creek, NDA 3716; Cedar Mt., NDA 3106. San Juan Co., Three Garden, SLW 12416. Uncommon.

Eriogonum inflatum **Torr. & Frem. var.** ***fusiforme*** **(Small) Reveal**

Utah: Kane Co., Cottonwood Wash road, Reveal et al. 823; 15 miles west of Glen Canyon City, NDA & RA 2869; 7 miles east of Glen Canyon City, NDA 2631; 10 miles east of Glen Canyon City, Olson 35. Abundant.

Eriogonum leptocladon **T. & G. var.** ***papiliunculum*** **Reveal**

Arizona: Coconino Co., between Page and Kaibito, Shaw 2646; Cockscomb, NDA & DK 3386; Paria Plateau, NDA 6412. **Utah:** Kane Co., Cedar Mt., NDA 3132; Church Wells, NDA & DK 3367. Endemic to sandy lower portion of Kaiparowits Basin; locally common.

Eriogonum microthecum **Nutt. var.** ***foliosum*** **(T. & G.) Reveal**

Arizona: Coconino Co., Paria Plateau, NDA 6408. **Utah:** Garfield Co., 1 mile south of Cannonville, NDA & DK 3316. Kane Co., Four Mile Bench, NDA 4302; 8 miles south of Cannonville, NDA & DK 3318; northwest of Cedar Mt., NDA et al. 2960; Smoky Mt., NDA & NW 3295; Nipple Bench, NDA & DK 3329; Cockscomb, NDA & DK 3378; Ahlstrom Point road, NDA & RA 2892. Widespread; common.

Eriogonum microthecum **Nutt. var.** ***laxiflorum*** **Hook.**

Utah: Kane Co., Fifty Mile Spring, JRM 359; Cockscomb, NDA 4614; Four Mile Bench, SLW & JRM 12398. Common.

Eriogonum palmerianum **Reveal**

Arizona: Coconino Co., Colorado Canyon, between Glen Canyon Dam and Lee's Ferry, NDA & LCH 4024; Paria Plateau, NDA 6402. **Utah:** Kane Co., NDA 4259; Cedar Mt., NDA 3105; Little Valley Canyon, NDA et al. 2730; 25 miles southeast of Escalante, Holmgren et al. 2061; Willow Tank, Harrison 9103. San Juan Co., east of Navajo Mt., NDA & DT 5347. Common.

Eriogonum panguicense **(Jones) Reveal var. *panguicense***

Utah: Garfield Co., Bryce Canyon, Cottam & Hutchings 2762. Rare and local; possibly threatened (Welsh et al. 1975).

Eriogonum racemosum **Nutt.**

Utah: Garfield Co., Bryce Canyon, Cottam 2755; Pet Hollow, NDA 4340. San Juan Co., Navajo Mt., NDA et al. 3000. Common.

Eriogonum salsuginosum **(Nutt.) Hook.**

Utah: San Juan Co., east of Navajo Mt., NDA & DT 5351. Rare.

Eriogonum scabrellum **Reveal**

Utah: Kane Co., Warm Creek, NDA & DK 3334; Smoky Mt., NDA 5958; Rock Creek, NDA & DK 3390. Edaphically restricted; uncommon (Utah endemic).

Eriogonum shockleyi **Wats. var. *longilobum* (Jones) Reveal**

Utah: Garfield Co., Escalante, Stanton 1047. Kane Co., Willow Tank, Beck & Tanner 2086; Harris Wash road, NDA & DT 5302; Ahlstrom Point road, NDA & RA 2892. Uncommon.

Eriogonum subreniforme **Wats.**

Arizona: Coconino Co., Cockscomb, NDA & RA 2879. **Utah:** Garfield Co., Tropic Valley, Holmgren et al. 2412; 1 mile east of Henrieville, NDA 1876. Uncommon.

Eriogonum umbellatum **Torr. var. *subaridum* Stokes**

Arizona: Coconino Co., Cockscomb, NDA et al. 3007; do, NDA 3071. **Utah:** Garfield Co., Pet Hollow, NDA 4332. San Juan Co., Iceberg Canyon, Lake Powell, NDA 4133; Navajo Mt., Gentry & Davidse 1777; do, NDA et al. 2966. Uncommon.

Eriogonum wetherillii **Eastw.**

Arizona: Coconino Co., Page vicinity, SLW & NDA 9772; do, Reveal 2911. **Utah:** Garfield Co., 45 miles south of Escalante, Beck & Tanner 8236. Kane Co., Warm Creek, NDA 3717; Paria River, NDA & LCH 3984; Little Valley Canyon, NDA et al. 2729. San Juan Co., east of Navajo Mt., 5348. Common.

Polygonum aviculare **L.**

Utah: Garfield Co., 45 miles south of Escalante, Beck & Tanner s.n. Rare.

Polygonum douglasii **Greene**

Utah: Garfield Co., Bryce Canyon, Buchanan 232 (Bryce). Rare.

Polygonum sawatchense **Small**

Utah: San Juan Co., Navajo Mt., NDA & DK 3400. Rare.

Rumex fueginus **Phil.**

Utah: Garfield Co., Escalante Canyon, Beck s.n., without date. Rare.

Rumex hymenosepalus **Torr.**

Arizona: Coconino Co., 3 miles south of Wahweap Marina, SLW & NDA 9766; Glen Canyon Dam vicinity, NDA & DT 3426. **Utah:** Kane Co., Willow Tank, Harrison 9094; 14 miles east of Glen Canyon City, RWA 323. Common.

Rumex venosus **Pursh.**

Utah: Kane Co., 15 miles west of Glen Canyon City, NDA & RA 2867. Rare.

POLYPODIACEAE (Fern Family)

Adiantum capillus-veneris **L.**

Arizona: Coconino Co., Paria Canyon, Woodruff 1127. **Utah:** Kane Co., Hole-in-the-Rock, Harrison 12137; Paria River, LCH & NDA 5388; 31.5 miles east of Glen Canyon City, NDA et al. 2705; Reflection Canyon, SLW & CAT 11859; mile 47, Lake Powell, NDA et al. 3236; Brigham Plains, NDA & RA 2801. San Juan Co., Three Garden, SLW & NDA 11673. Hanging gardens; abundant.

Cheilanthes feei **Moore**

Utah: Kane Co., Cockscomb, NDA 4628. Rare.

Pellaea longimucronata **Hook.**

Utah: San Juan Co., Trail Canyon, Lake Powell, SLW 11910. Rare.

PORTULACACEAE (Purslane Family)

Lewisia pygmaea **(Gray) Robins.**
Utah: San Juan Co., Navajo Mt., NDA 4182. Rare.

Portulaca mundula **Johnst.**
Arizona: Coconino Co., Paria Plateau, NDA & GM 4281. **Utah:** Kane Co., Cedar Mt., NDA et al. 3255, do, NDA 3104A. Rare.

Portulaca oleracea **L.**
Utah: Kane Co., Cockscomb, NDA & DK 3376. Rare.

Talinum breviflorum **Torr.**
Arizona: Coconino Co., north of Shouts, NDA & DT 5330. Rare.

Talinum parviflorum **Nutt.**
Arizona: Coconino Co., Cockscomb, NDA 3061. **Utah:** Kane Co., Cedar Mt., NDA et al. 3253. Rare.

PRIMULACEAE (Primrose Family)

Androsace septentrionalis **L.**
Utah: Garfield Co., Escalante Canyon, Beck s.n. Kane Co., Cockscomb, NDA 4618. San Juan Co., Navajo Mt., Gentry & Davidse 1771. Uncommon.

Dodecatheon pulchellum **(Raf.) Merrill**
Utah: Kane Co., Little Valley Canyon, SLW & NDA 11611. Rare.

Primula specuicola **Rydb.**
Utah: Kane Co., Hole-in-the-Rock, Karren 102. San Juan Co., Three Garden, SLW & NDA 11668; do, SLW 11905; east of confluence of San Juan, NDA & RA 3157; do, NDA 4092. Restricted, local, and threatened (Welsh et al. 1975).

POTAMOGETONACEAE (Pondweed Family)

Potamogeton pusillus **L.**
Utah: Kane Co., Escalante Canyon, NDA 4208. Rare.

PYROLACEAE (Wintergreen Family)

Pterospora andromedea **Nutt.**
Utah: Garfield Co., Bryce Canyon, Vogt s.n. (Bryce). Rare.

Pyrola secunda **L.**
Utah: San Juan Co., Navajo Mt., NDA 4189; do, Gentry & Davidse 1773. Rare.

RANUNCULACEAE (Buttercup Family)

Aconitum columbianum **Nutt.**
Utah: Garfield Co., Escalante Canyon, Beck s.n., 1936. Rare.

Anemone tuberosa **Rydb.**
Utah: San Juan Co., Rainbow Bridge, NDA 3561. Rare.

Aquilegia coerulea **James**
Utah: Garfield Co., Buchanan 161 (Bryce). Rare.

Aquilegia formosa **Fisch.**
Utah: Kane Co., Four Mile Bench, SLW & BW 12440; do, SLW 12573a. Rare.

Aquilegia micrantha **Eastw.**
Arizona: Coconino Co., Paria Canyon, Woodruff 1137. **Utah:** Kane Co., Four Mile Bench, SLW & BW 12440a; 31.5 miles east of Glen Canyon City, NDA et al. 2698; Last Chance Canyon, 3 miles north of Four Mile Spring, NDA 4076; Escalante River, NDA 4225; do, SLW & GM 11817; Crosby Canyon, NDA & RA 2889. San Juan Co., Three Garden, SLW & NDA 11691; Rainbow Bridge, SLW & NDA 11658. Abundant; hanging gardens.

Aquilegia scopulorum **Tidestr.**
Utah: Garfield Co., Bryce Canyon, Cottam 2764. Rare.

Aquilegia shockleyi **Eastw.**
Utah: Garfield Co., Escalante, Cottam 4383, 4390; north of Escalante, NDA 440. Rare.

Clematis ligusticifolia **Nutt.**
Utah: Kane Co., Willow Tank, Beck & Tanner s.n.; Wahweap Bay, NDA 3135. San Juan Co., east of confluence of San Juan, NDA & RA 3191. Abundant.

Clematis pseudoalpina **(Kuntze) A. Nels.**
Utah: Garfield Co., Death Ridge, NDA 5184; Canaan Peak, SLW 12829; do, SLW 12878. Rare.

Delphinium menziesii **DC. ssp. *utahense* (Wats.) Sutherland**
Utah: Kane Co., Kaiparowits Plateau, Harrison 9050; do, NDA 5227. Rare.

Delphinium scaposum **Greene**
Arizona: Coconino Co., Paria Plateau, NDA & LCH 3783. **Utah:** Garfield Co., 1.5 miles south of Cannonville, Reveal et al. 767. Kane Co., 40 miles east of Kanab, Cronquist 10141; Hole-in-the-Rock, White 115; Kaiparowits Plateau, NDA & DT

5261; Dry Rock Creek, Lake Powell, SLW & NDA 11614; Cedar Mt., RWA 337. Abundant.

Myosurus minimus **Pallas**

Arizona: Coconino Co., Buckskin Mt., NDA 4933. Rare.

Ranunculus aquatilis **L.**

Utah: Garfield Co., Escalante, Cottam 4431. Rare.

Ranunculus cymbalaria **Pursh.**

Arizona: Coconino Co., Colorado Canyon, between Glen Canyon Dam and Lee's Ferry, NDA & LCH 4023. Rare.

Ranunculus glaberrimus **Hook. var. *ellipticus*** **Greene**

Utah: San Juan Co., NDA & DT 5344. Rare.

Ranunculus juniperinus **Jones**

Utah: Kane Co., Cockscomb, NDA 3583. Rare.

Ranunculus orogenes **Greene**

Utah: San Juan Co., Navajo Mt., NDA 4186. Rare.

Thalictrum fendleri **Engelm.**

Utah: San Juan Co., Navajo Mt., NDA et al. 2993. Rare.

RHAMNACEAE (Buckthorn Family)

Ceonothus fendleri **Gray.**

Utah: San Juan Co., Navajo Mt., Gentry & Davidse 1967; do, NDA et al. 2974. Uncommon; higher elevations.

Ceonothus martini **Jones**

Utah: Garfield Co., Bryce Canyon, Boyle 1113. Uncommon; higher elevations.

Rhamnus betulaefolia **Greene**

Arizona: Coconino Co., Navajo Creek, NDA 3723. **Utah:** Garfield Co., Escalante Canyon, Beck s.n. Kane Co., 31.5 miles east of Glen Canyon City, NDA et al. 2699; Escalante Canyon, SLW & GM 11813; Hole-in-the-Rock, Harrison 12107; Reflection Canyon, SLW & CAT 11848. San Juan Co., east of confluence of San Juan, NDA & RA 3167; Three Garden, SLW 12422. Canyons and hanging gardens at lower elevations; common.

ROSACEAE (Rose Family)

Amelanchier utahensis **Koehne**

Utah: Garfield Co., Cottam 4375. Kane Co., Tibbet Canyon, NDA 3460; 20 miles south of Cannonville, Christensen s.n.; Kaiparowits Plateau, NDA & DT 5264; Paria Townsite, SLW & NDA 9732; Four Mile Bench, NDA 3759; Cottonwood Wash, NDA 3593; Tibbet Canyon, NDA 3460; Warm Creek, NDA & RA 2853. Common.

Cercocarpus intricatus **Wats.**

Utah: Garfield Co., Escalante, Cottam 4416; do, Beck & Tanner s.n. Kane Co., Kaiparowits Plateau, Harrison 9081; Four Mile Bench, NDA et al. 3505. Uncommon.

Cercocarpus montanus **Raf.**

Utah: Garfield Co., Bryce Canyon, Harrison 12322. Kane Co., Kaiparowits Plateau, NDA & DT 5265. Uncommon.

Chamaebatiaria millefolium **(Torr.) Maxim.**

Utah: Kane Co., Cockscomb, NDA 4410. Rare.

Coleogyne ramosissima **Torr.**

Arizona: Coconino Co., Page vicinity, SLW & NDA 9786; 5 miles southeast of Page, Nebeker & Skougard 197; 8 miles south of Page, RWA 224. **Utah:** Cedar Mt., NDA et al. 2752; 35 miles southeast of Escalante, Harrison 9117; Grand Bench, NDA 3536; Hole-in-the-Rock, White 124; 14 miles east of Glen Canyon City, RWA 321; Dry Rock Creek, Lake Powell, SLW & NDA 11638. Codominant in blackbrush communities; abundant.

Cowania mexicana **D. Don**

Arizona: Coconino Co., Cedar Mt., NDA et al. 2754. **Utah:** Kane Co., Willow Tank, Harrison 9112; 50 miles southeast of Escalante, Beck & Tanner s.n.; Dry Rock Creek, Lake Powell, SLW & NDA 11630; Cockscomb, SLW 5336; Cedar Mt., RWA 184; Four Mile Bench, SLW & JRM 12412. San Juan Co., Navajo Mt., NDA 4142; do, NDA et al. 2983. Widespread; uncommon.

Fallugia paradoxa **(D. Don) Endl.**

Utah: Kane Co., Paria River, NDA & RA 2779; Kaiparowits Plateau, NDA & DT 5291, Cockscomb, JRM 340; Tibbet Canyon, NDA 3760; Little Valley Canyon, NDA et al. 2717; 5 miles east of Paria, Harrison 12311. Canyon bottoms; locally common.

Holodiscus dumosus **(Nutt.) Heller**

Utah: Garfield Co., Bryce Canyon, Cottam 2780; Escalante, Cottam 4373. Kane

Co., Hackberry Canyon, NDA 3690. Rare.

Ivesia sabulosa **(Jones) Keck**

Arizona: Coconino Co., Paria Plateau, NDA & GM 4295. Possibly threatened (Welsh et al. 1975).

Peraphyllum ramosissimum **Nutt.**

Utah: Garfield Co., Bryce Canyon, Buchanan 219. Rare.

Petrophytum caespitosum **(Nutt.) Rydb.**

Utah: Kane Co., Reflection Canyon, SLW & CAT 11857. San Juan Co., east of confluence of San Juan, NDA et al. 3226. Hanging gardens; locally abundant.

Potentilla anserina **L.**

Utah: Garfield Co., Bryce Canyon, Weight s.n. Uncommon.

Potentilla concinna **Richards.**

Utah: Garfield Co., Canaan Peak, NDA & DT 5320. San Juan Co., Navajo Mt., NDA & DT 5345; do, NDA 4172, 4173. Higher elevations; uncommon.

Prunus virginiana **L.**

Utah: Kane Co., Kaiparowits Plateau, NDA & DT 5230. Rare.

Purshia tridentata **(Pursh) DC.**

Utah: Garfield Co., Bryce Canyon, Harrison 12041. Kane Co., Cockscomb, NDA 3540; Kaiparowits Plateau, Harrison 9080. Uncommon.

Rosa neomexicana **Cockerell**

Utah: San Juan Co., Navajo Mt., NDA 4135; do, NDA et al. 2999. Rare.

Rosa woodsii **Lindl.**

Utah: Garfield Co., Escalante, Cottam 4421; do, Beck & Tanner 8235. Kane Co., Hole-in-the-Rock, Harrison 12139. San Juan Co., Ribbon Canyon, NDA 4103. Uncommon.

Rubus neomexicanus **Gray**

Utah: San Juan Co., Ribbon Canyon, SLW & NDA 11710; do, SLW & GM 11782; do, NDA 4102. This is the first known Utah record; rare.

RUBIACEAE (Madder Family)

Galium bifolium **Wats.**

Utah: Kane Co., Kaiparowits Plateau, NDA & DT 5222. Uncommon.

Galium stellatum **Kellogg**

Utah: Garfield Co., Escalante, Cottam 4411. Kane Co., Driftwood Canyon, Lake Powell, SLW & NDA 11644. Rare.

RUTACEAE (Rue Family)

Ptelea trifoliata **L. ssp. *pallida* (Greene) V.L. Bailey**

Utah: Garfield and Kane counties, Bailey (1962), possibly extinct.

Thamnosoma montana **Torr. & Frem.**

Arizona: Coconino Co., Glen Canyon Dam, NDA & DT 3424; Navajo Canyon, NDA & RA 3145. Kane Co., Cedar Mt., NDA 4425. Rare.

SALICACEAE (Willow Family)

Populus angustifolia **James**

Utah: Garfield Co., Bryce Canyon, Weight B-31/148. Higher elevations; uncommon.

Populus fremontii **Wats.**

Utah: Kane Co., Little Valley Canyon, NDA 3428, 3419. Drainage bottoms; common.

Populus tremuloides **Michx.**

Utah: San Juan Co., Navajo Mt., NDA et al. 2988. Rare to uncommon.

Salix amygdaloides **Anderss.**

Utah: Kane Co., Escalante Canyon, NDA & RA 3214; Reflection Canyon, SLW & CAT 11856. San Juan Co., Ribbon Canyon, NDA 4106. Uncommon.

Salix bebbiana **Sarg.**

Utah: San Juan Co., Navajo Mt., NDA 4166. Uncommon.

Salix exigua **Nutt.**

Utah: Garfield Co., Bryce Canyon, Cottam 2779; Escalante, Cottam 4397. Kane Co., Nipple Canyon, NDA & RA 2833; Four Mile Bench, SLW et al. 12585; Paria River, NDA & LCH 4010. Common; drainages, seeps, and springs.

Salix lutea **Nutt.**

Utah: San Juan Co., Three Garden vicinity, SLW 11894. Uncommon.

Salix scouleriana **Barrett**

Utah: San Juan Co., Navajo Mt., NDA et al. 2989. Uncommon.

SANTALACEAE (Sandalwood Family)

Comandra umbellata **(L.) Nutt. var. *pallida* (A. DC.) Jones**

Utah: Garfield Co., 1.3 miles south of Cannonville, Reveal et al. 747. Kane Co., Kaiparowits, Plateau, NDA & DT 5278; East Clark Bench, NDA & RA 2685; Fifty Mile Spring, JRM 369; Cedar Mt., RWA 187; Cockscomb, NDA 3539, 1972; Four Mile Bench, SLW 12430. Common.

SAXIFRAGACEAE (Saxifrage Family)

***Heuchera rubescens* Torr.**
Utah: Garfield Co., Escalante, Cottam 4410. San Juan Co., Navajo Mt., Gentry & Davidse 1781; do, NDA 4188. Rare.

***Lithophragma tenella* Nutt.**
Arizona: Coconino Co., Cockscomb, NDA 4942. **Utah:** Kane Co., Kaiparowits Plateau, Harrison 9049. San Juan Co., Navajo Mt., NDA & DT 5337. Uncommon.

***Philadelphus microphyllus* Gray**
Utah: San Juan Co., Navajo Mt., Gentry & Davidse 1768; do, NDA et al. 2980. Rare.

***Ribes cereum* Dougl.**
Utah: Garfield Co., Bryce Canyon, Buchanan 105. Uncommon.

***Ribes leptanthum* Gray**
Utah: Kane Co., Kaiparowits Plateau, NDA 529; do, NDA & DT 5266. San Juan Co., NDA 4134. Uncommon.

***Ribes montigenum* McClatchie**
Utah: San Juan Co., Navajo Mt., NDA 4153. Rare.

***Ribes velutinum* Greene**
Utah: Kane Co., Buckskin Mt., NDA 4649. Rare.

SCROPHULARIACEAE (Figwort Family)

***Castilleja chromosa* A. Nels.**
Utah: Garfield Co., Escalante, Cottam 4415; 1.5 miles south of Cannonville, Reveal et al. 766; 20 miles southeast of Cannonville, Holmgren et al. 2049. Kane Co., Kaiparowits Plateau, Harrison 9055; Bryce Canyon, NDA 6127; 14 miles east of Glen Canyon City, RWA 213; Smoky Mt., Cronquist 10020; Cottonwood Wash road, Reveal et al. 808; Paria Townsite, SLW & NDA 9724; Buckskin Gulch, SLW 5310; Nipple Canyon, NDA 3479; Four Mile Bench, SLW & NDA 12377; Brigham Plains, NDA et al. 3488. San Juan Co., Three Garden, SLW 12415; Navajo Mt., NDA 4140. Abundant.

***Castilleja exilis* A. Nels.**
Utah: Garfield Co., Escalante Canyon, Beck 113; do, Holmgren et al. 2119. Rare.

***Castilleja linariaefolia* Benth.**
Arizona: Coconino Co., Paria Plateau, NDA 6397. **Utah:** Garfield Co., 5 miles west of Escalante, Anderson 684. Kane Co., Reflection Canyon SLW 11882; Hole-in-the-Rock, Harrison 12106; Escalante Canyon, NDA & RA 3206; Four Mile Bench, SLW et al. 12579; Cottonwood Wash road, NDA & DK 3321; Hole-in-the-Rock, Karren 105; east of confluence of San Juan, NDA & RA 3174, 3186; Navajo Mt., Gentry & Davidse 1783; do, NDA et al. 2972. Abundant.

***Castilleja revealii* N. Holmgren**
Utah: Garfield Co., Bryce Canyon, Holmgren & Reveal 2017. Rare, endemic, and possibly endangered (Welsh et al. 1975).

***Castilleja scabrida* Eastw.**
Utah: Garfield Co., 12 miles east of Escalante, Harrison 9129; southeast of Escalante, NDA 1242. Kane Co., 16 miles east of Glen Canyon City, NDA 3666. Common.

***Collinsia parviflora* Dougl.**
Utah: San Juan Co., NDA & DT 5340; do, NDA 4185. Rare.

***Cordylanthus parviflorus* (Ferris) Wiggins**
Utah: Kane Co., 30 miles east of Kanab, NDA 5587. Rare.

***Cordylanthus wrightii* Gray**
Arizona: Coconino Co., Paria Plateau, NDA 6413. **Utah:** Kane Co., Escalante River, NDA 4222; East Clark Bench, NDA & DK 3372; Cedar Mt., NDA 3110. Uncommov.

***Mimulus eastwoodiae* Rydb.**
Utah: Kane Co., Escalante River, NDA & RA 3202, 3217, 3219. San Juan Co., Rainbow Bridge, NDA & NW 3303; Three Garden, SLW & NDA 11677. Hanging gardens; restricted and uncommon.

***Mimulus glabratus* H.B.K.**
Utah: Kane Co., Cottonwood Wash, SLW 12591; do, NDA & LCH 3833. Uncommon.

Mimulus guttatus* Fisch. var. *guttatus
Arizona: Coconino Co., Paria Canyon, Woodruff 1131, 1132. Uncommon.

***Mimulus guttatus* DC. var. *depauperatus* (Gray) Grant**
Utah: Kane Co., Escalante Canyon, NDA & RA 3205. Uncommon.

Mimulus rubellus Gray
Arizona: Coconino Co., Cockscomb, NDA 4932, 4946. **Utah:** Kane Co., Cockscomb, NDA 4620; Buckskin Mt., NDA 4655. San Juan Co., Navajo Mt., NDA & DT 5343. Uncommon.

Mimulus suksdorfii Gray
Utah: Kane Co., Kaiparowits Plateau, NDA & DT 5221. Uncommon.

Orthocarpus purpureo-albus Gray
Utah: Garfield Co., Bryce Canyon, Weight s.n. Uncommon.

Pedicularis centranthera Gray
Utah: Garfield Co., Bryce Canyon, Burkey 135; Death Ridge, NDA 5179. Kane Co., Cottonwood Wash road, LCH & NDA 5254. San Juan Co., Navajo Mt., NDA et al. 2995; do, NDA 4158. Uncommon.

Penstemon ambiguus Torr.
Arizona: Coconino Co., Glen Canyon Dam vicinity, Reveal et al. 838, Paria Plateau, NDA & GM 4280. **Utah:** Garfield Co., Escalante, NDA 747. Kane Co., 50 miles south of Escalante, Beck & Tanner s.n.; East Clark Bench, NDA & RA 2683; Paria River, NDA & LCH 3942; Cedar Mt., NDA 3120A. San Juan Co., east of confluence of San Juan, NDA 4096. Low elevations; common.

Penstemon angustifolius Nutt. ssp. *elatus* Crosswhite
Utah: Garfield Co., Escalante, Cottam 4385a; east of Escalante, Harrison 9136b. Uncommon.

Penstemon barbatus (Cav.) Roth. ssp. *torreyi* (Benth.) Keck
Utah: Garfield Co., north of Escalante, Holmgren et al. 2423. Rare.

Penstemon bracteatus Keck
Utah: Garfield Co., Bryce Canyon, Holmgren et al. 2018. Rare.

Penstemon bridgesii Gray
Arizona: Coconino Co., Paria Plateau, NDA & GM 4276. **Utah:** Garfield Co., Pet Hollow, NDA 4322. Kane Co., Cockscomb, NDA 5485. San Juan Co., NDA & DK 3398; do, NDA et al. 2964; do, Gentry & Davidse 1793. Uncommon.

Penstemon caespitosus Nutt. ssp. *perbrevis* Pennell
Utah: Garfield Co., Bryce Canyon, Boyle 1138; Utah endemic; restricted edaphically and uncommon.

Penstemon comarrhenus Gray
Utah: Garfield Co., Bryce Canyon, Cottam 2757; Escalante, Cottam 4386; Kane Co., Four Mile Bench, NDA 5357; Collet Wash, NDA 1869; 25 miles southeast of Escalante, Holmgren et al. 2059. San Juan Co., Navajo Mt., Gentry & Davidse 1780; do, NDA et al. 2965. Middle elevations; widespread and uncommon.

Penstemon confusus Jones
Utah: Garfield Co., Escalante, White 137. Kane Co., Four Mile Bench, SLW 12427. Uncommon.

Penstemon eatonii Gray ssp. *undosus* (Jones) Keck
Utah: Garfield Co., Escalante, Cottam 4386a. Kane Co., Hole-in-the-Rock, Harrison 12116; Cockscomb, SLW 5344; Kaiparowits Plateau, NDA & DT 5260.

Penstemon jamesii Benth. ssp. *ophianthus* (Pennell) Keck
Utah: Garfield Co., 11 miles east of Henrieville, Holmgren et al. 2019; Death Ridge, NDA 5177. Kane Co., Collet Wash, NDA s.n. Uncommon.

Penstemon laevis Pennell
Utah: Garfield Co., near Bryce Canyon, Burkey 165. Kane Co., Cottonwood Wash, NDA & RA 2803; Paria River, NDA & LCH 3998; 3 miles north of Four Mile Spring, NDA 4080. Uncommon.

Penstemon leiophyllus Pennell
Utah: Garfield Co., Bryce Canyon, Weight 6663. Kane Co., Bryce Canyon, Boyle 1131. Uncommon and possibly threatened (Welsh et al. 1975).

Penstemon lentus Pennell ssp. *lentus*
Utah: Garfield Co., Escalante, Cottam 4419. Rare.

Penstemon pachyphyllus Gray
Utah: Garfield Co., Escalante, Cottam 4425. Kane Co., 4 miles south of Cannonville, Reveal 782. Uncommon.

Penstemon palmeri Gray
Utah: Kane Co., Paria River, NDA & LCH 3999; Warm Creek, NDA & RA 2852; Last Chance Creek, 3 miles north of Four Mile Spring, NDA 4081; Collet Wash, NDA 1871. Uncommon.

Penstemon thompsoniae (Gray) Rydb.

Arizona: Coconino Co., Cockscomb, NDA 4945. **Utah:** Kane Co., Four Mile Bench, RWA 439; do, NDA 5170. Rare.

Penstemon utahensis **Eastw.**

Utah: Garfield Co., Bryce Canyon, Cottam 4354; 4 miles southwest of Cannonville, Reveal et al. 769. Kane Co., Kaiparowits Plateau, Harrison 9061, 9065; Cockscomb, NDA 3546; Buckskin Gulch, SLW 5306; Little Valley Canyon, NDA 3521; Cottonwood Wash, Moore 403; Smoky Mt., Cronquist 10021; Paria Townsite, SLW & NDA 9725; 3 miles southeast of Escalante, Buss 107; Fifty Mile Spring, JRM 353. San Juan Co., Navajo Mt., King s.n. Common.

Penstemon venosus **(Keck) Reveal**

Utah: Garfield Co., east of Escalante, Harrison 9136a. Uncommon

Veronica anagallis-aquatica **L.**

Arizona: between Lee's Ferry and Glen Canyon Dam, NDA & LCH 4020. **Utah:** Kane Co., Escalante Canyon, NDA 4129. Uncommon.

SOLANACEAE (Nightshade Family)

Chamaesarcha coronopus **(Dunal) Gray**

Arizona: Coconino Co., Cockscomb, NDA & RA 2888a. Uncommon.

Datura meteloides **DC.**

Utah: Kane Co., Willow Tank, Harrison 9092; Hole-in-the-Rock, Harrison 12109; base of Cedar Mt., NDA 2917; Escalante Canyon, NDA & RA 3199; do, SLW & GM 11808. Low elevations; common.

Lycium andersonii **Gray**

Utah: Kane Co., Last Chance Creek, NDA et al. 3515; base of Smoky Mt., NDA 3440. Uncommon.

Lycium pallidum **Miers**

Arizona: Coconino Co., Paria Plateau, NDA & LCH 3785; Cedar Mt., NDA et al. 2749. **Utah:** Kane Co., Cedar Mt., NDA 3559. Uncommon.

Nicotiana attenuata **Torr.**

Utah: San Juan Co., Navajo Mt., Gentry & Davidse 1789; do, NDA et al. 2968; do, NDA & DK 3397. Uncommon.

Nicotiana trigonophylla **Dunal**

Arizona: Coconino Co., east side of Glen Canyon Dam, NDA 3449. **Utah:** Kane Co., Wahweap Bay, Lake Powell, NDA 3701; Escalante Canyon, SLW & GM 11807; Dry Rock Creek, Lake Powell, SLW & NDA 11631; Gunsight Bay, Lake Powell, SLW & NDA 11583. Uncommon.

Physalis fendleri **Gray**

Arizona: Coconino Co., Paria Plateau, NDA & GM 4292. Rare.

Solanum elaeagnifolium **Cav.**

Utah: Kane Co., 6 miles west of Glen Canyon City, NDA 2922. Rare.

Solanum triflorum **Nutt.**

Utah: Kane Co., Willow Tank, Beck & Tanner s.n.; Escalante Canyon, SLW & GM 11806. Rare.

TAMARICACEAE (Tamatix Family)

Tamarix parvifolia **DC.**

Utah: Kane Co., Paria River, NDA 3577. Uncommon.

Tamarix ramosissima **Ledeb.**

Arizona: Coconino Co., between Lee's Ferry and Glen Canyon Dam, NDA & LCH 4034. **Utah:** Kane Co., Hole-in-the-Rock, Harrison 12120; Paria River, Cronquist 10200; Cottonwood Wash road, NDA & RA 2768; Halls Creek Bay, Lake Powell, SLW & GM 11794; Four Mile Bench, SLW et al. 12582. Abundant.

TYPHACEAE (Cattail Family)

Typha domingensis **Pers.**

Utah: Kane Co., Escalante Canyon, NDA 4214; Four Mile Bench, SLW et al. 12602. Uncommon.

ULMACEAE (Elm Family)

Celtis reticulata **Torr.**

Arizona: Coconino Co., Lee's Ferry, Cottam 2625. **Utah:** Kane Co., Hole-in-the-Rock, Harrison 12108; Escalante Canyon, SLW & GM 11818; Reflection Canyon, SLW & CAT 11860. San Juan Co., Three Garden, SLW & NDA 11689; east of confluence of San Juan, NDA & RA 3181A. Canyons; locally common.

UMBELLIFERAE (Parsley Family)

Cymopterus fendleri **Gray**

Utah: Kane Co., Willow Tank, JRM 387a;

base of Smoky Mt., NDA 3439; East Clark Bench, NDA et al. 3493; 30 miles east of Glen Canyon City, NDA 4549; Little Valley Canyon, NDA 3530. Common.

Cymopterus newberryi (Wats.) Jones
Arizona: Coconino Co., 3 miles south of Wahweap Marina, SLW & NDA 9769. **Utah:** Kane Co., 14 miles east of Glen Canyon City, RWA 119; 6 miles southeast of Glen Canyon City, RWA 133; between Nipple Bench and Lake Powell, Cronquist 10016; Paria River, NDA & LCH 3964; Warm Creek, NDA 3714; Willow Tank, JRM 387. Common.

Cymopterus multinervatus (C. & R.) Tidestr.
Utah: Kane Co., Cottonwood Wash Road, SLW 5357; Paria Townsite, SLW & NDA 9726; Cockscomb, NDA 4665; East Clark Bench, NDA et al. 3494; 13 miles east of Warm Creek, NDA et al. 3511. Low elevations; common.

Cymopterus purpurascens (Gray) Jones
Utah: Kane Co., Nipple Canyon, NDA 3481; Cedar Mt., RWA 171; Smoky Mt., RWA 126. Common.

Cymopterus purpureus Gray
Arizona: Coconino Co., Cockscomb, NDA 4926. **Utah:** Kane Co., Kaiparowits Plateau, Harrison 9064; do, JRM 406; Buckskin Gulch, SLW 5317; Cottonwood Wash road, Christensen s.n.; Nipple Creek, NDA 3483; Cockscomb, NDA 4630A. Common.

Lomatium foeniculaceum (Nutt.) C. & R. var. *macdougalii* (C. & R.) Cronq.
Arizona: Coconino Co., Cockscomb, NDA 4934. **Utah:** Kane Co., Four Mile Bench, NDA et al. 3506. Uncommon.

Lomatium juniperinum (Jones) C. & R.
Utah: Garfield Co., NDA & DT 5319. Rare.

Lomatium minimum Mathias
Utah: Garfield Co., Bryce Canyon, Cottam, Harrison & Stanton 4360; do, Weight s.n., Aug. 1934. Endemic, rare, and threatened (Welsh et al. 1975).

Lomatium nevadense (Wats.) C. & R.
Utah: Kane Co., Kaiparowits Plateau, Harrison 9047; do, NDA & DT 5247. Rare.

Lomatium parryi (Wats.) Macbr.
Arizona: Coconino Co., 9 miles south of Page, RWA 219. **Utah:** San Juan Co., Navajo Mt., NDA 4144. Uncommon.

URTICACEAE (Nettle Family)

Parietaria pennsylvanica Muhl.
Utah: Kane Co., Escalante Canyon, SLW & GM 11805; Cockscomb, NDA 4413; do, NDA 4627. Uncommon.

VIOLACEAE (Violet Family)

Viola canadensis L.
Utah: San Juan Co., Navajo Mt., NDA 4155. Rare.

Viola nephrophylla Greene
Utah: Garfield Co., Escalante Canyon, Harrison 9148. Rare.

VISCACEAE (Dwarf Mistletoe Family)

Arceuthobium vaginatum (H.B.K.) Eichler
Utah: San Juan Co., Navajo Mt., NDA et al. 2991. Uncommon.

Phoradendron juniperinum Engelm.
Utah: Kane Co., Four Mile Bench, NDA 4308; Cockscomb, NDA 3547. Common.

VITACEAE (Grape Family)

Parthenocissus inserta (Kerner) K. Frtsch.
Utah: Kane Co., Hole-in-the-Rock, Harrison 12138; Escalante Canyon, SLW & GM 11816; do, SLW & CAT 11872; do, NDA 4127; Reflection Canyon, SLW & CAT 11853. San Juan Co., Rainbow Bridge, SLW & NDA s.n. Uncommon.

ZANNICHELLIACEAE
(Horned Pondweed Family)

Zannichellia palustris L.
Arizona: Coconino Co., Lee's Ferry, NDA 4350. Reflection Canyon, SLW & CAT 11855. Uncommon.

ZYGOPHYLLACEAE (Caltrop Family)

Tribulus terrestris L.
Arizona: Coconino Co., 8 miles southeast of Page, NDA et al. 3241; Paria Plateau, NDA & GM 4289. Uncommon.

LITERATURE CITED

(Plants)

AL-SHEBAZ, I. A. 1973. The biosystematics of the genus *Thelypodium* (Cruciferae). Contr. Gray Herb. 204: 1–148.

BAILEY, V. L. 1962. Revision of the genus *Ptelea* (Rutaceae). Brittonia 14:1–45.

BARNEBY, P. C. 1964. Atlas of North American *Astragalus*. Mem. N.Y. Bot. Gard. 13:1–1188.

BUCHANAN, H., AND G. T. NEBEKER. 1971. Checklist of higher plants of Bryce Canyon National Park, Utah. Weber State College, Ogden, Utah. 30 pp.

______. 1974. Wildflower communities of Bryce Canyon and Cedar Breaks. Bryce Canyon Natural History Association, Bryce Canyon, Utah. 25 pp.

CLOVER, E. U., AND L. JOTTER. 1941. Cacti of the Colorado River and tributaries. Bull. Torrey Bot. Club 68:409–419.

EASTWOOD, A. 1893. Plants collected in southeastern Utah. Zoe 4:123–125.

FLOWERS, S. 1959. Vegetation in Glen Canyon, pp. 21–61. *In*: Ecological studies of the flora and fauna in Glen Canyon, Angus M. Woodbury et al. Univ. Utah Anthro. Papers No. 40, Glen Canyon Ser. No. 7:63–72.

GAINES. X. M. 1957. Plants in Glen Canyon Plateau 30(2):31–34.

______. 1960. An annotated catalogue of Glen Canyon plants. Museum of Northern Arizona Technical Series, No. 4.

GREGORY, H. E. 1947. Colorado drainage basin. Amer. J. Sci. 245:694–705.

HARING, I. N. 1961. Mosses of the Glen Canyon area. Plateau 33(4):120–22.

HARRINGTON, H. D. 1954. Manual of the plants of Colorado. Sage Books, Denver, Colorado. 666 pp.

HASKELL, H. S. 1958. Flowering plants in Glen Canyon—late summer aspect. Plateau 31(1):1–3.

KEARNEY, T. H., AND R. H. PEEBLES. 1964. Arizona flora. University of California Press, Berkeley. 1085 pp.

LINDSAY, D. S. 1959. Vascular plants collected in Glen Canyon. Appendix A in Ecological studies of the flora and fauna in Glen Canyon, Angus M. Woodbury et al. Univ. Utah Anthro. Papers No. 40, Glen Canyon Ser. No. 25:176–195.

MARTIN, P. S. 1964. Pollen analysis in the Glen Canyon. Addendum in 1962 excavation, Glen Canyon area, Floyd W. Sharrock, et al. Univ. Utah Anthro. Papers. No. 73, Glen Canyon Ser. No. 25:176–195.

MCDOUGALL, W. B. 1959. Plants of the Glen Canyon area in the herbarium of the Museum of Northern Arizona. Museum of Northern Ariz., Flagstaff. Mimeographed.

MORGAN, D. L. 1947. The exploration of the Colorado River in 1869. Utah Hist. Quarterly 15. 270 pp.

PLAIR, T. B. (1939). Vegetative cover of the Utah Parks. Zion and Bryce Nat. Notes 6(3):34–35.

REVEAL, J. L. 1970. Comments on *Lesquerelia hitchcockii*. Great Basin Nat. 30:94–98.

TIDESTROM, I. 1925. Flora of Utah and Nevada. Contr. U.S. Natl. Herb. 25:1–665.

WEIGHT, K. E. 1932. The limber pine. Zion and Bryce Nat. Notes. 4(5):4.

______. 1933. The bristle-cone pine in Bryce Canyon Natl. Park. Zion and Bryce Nat. Notes 5(3):8.

______. 1933. Douglas fir in Bryce Canyon Zion and Bryce Nat. Notes 5(4):4–5.

WELSH, S. L. AND G. MOORE. 1973. Utah plants tracheophyta. Brigham Young University Press, Provo, Utah. 474 pp.

WELSH, S. L., N. D. ATWOOD, AND J. L. REVEAL. 1975. Endangered, threatened, extinct, endemic, and rare or restricted Utah vascular plants. Great Basin Nat. 35:327–376.

LITERATURE CITED

(General Biota Including Plants)

ADAMS, E. B., AND A. CHAVEX. 1956. The missions of New Mexico, 1776, a description, with other contemporary documents. University of New Mexico Press, Albuquerque. 387 pp.

ARRINGTON, L. J. 1958. Great Basin kingdom, an economic history of Latter-day Saints, 1830–1900. Harvard Univ. Press, Cambridge, Mass. 524 pp.

AUERBACK, H. S. 1943. Father Escalante's journal with related documents and maps. Utah Hist. Quart. 11:1–10.

BAKER, A. A. 1936. Geology of the Monument Valley-Navajo Mountain Region, San Juan County, Utah. U.S. Geological Bull. No. 865. Washington, D.C. 106 pp.

BANCROFT, H. H. 1889. History of Utah, 1540–1886. San Francisco History Co., 1889. Arno Press, New York. 808 pp.

BENSON, S. B. 1935. Biological reconnaisance of Navajo Mountain. Univ. of Calif. Publ. in Zool. 40(14):439–456.

BERNHEIMER, C. L. 1923. Encircling Navajo Mountain with a pack train—a new route to Rainbow Natural Bridge. Natl. Geogr. Mag. 43:197–224.

BOLTON, H. E. 1950. Pageant in the wilderness, the story of the Escalante expedition to the Interior Basin, 1776, including the diary and itinerary of Father Escalante; translated and annotated. State Historical Society. 265 pp.

BROOKS, J. 1957. Lee's Ferry at Lonely Dell. Utah Hist. Quarterly 25:283–295.

BRIGHAM YOUNG UNIVERSITY NAVAJO-KAIPAROWITS REFERENCE COLLECTION. 1971–1974. Brigham Young University, Provo, Utah.

CHAMBERLIN, R. V. 1947. Francis Marion Bishop, 1843–1933. Utah Hist. Quarterly 25:155–158.

CHIDESTER, I., AND E. BRUIN. (Daughters of Utah Pioneers). 1949. Golden nuggets of pioneer days, a history of Garfield County. Garfield County News, Panguitch, Utah.

CLELAND, R. G. 1963. This reckless breed of men, the trappers and fur traders of the Southwest. Knopf, New York. 361 pp.

CRAMPTON, G. C. 1959. Outline history of the Glen

Canyon region. Univ. Utah Papers No. 42, Glen Canyon Ser. No. 9:1–137.

Creer, L. H. 1958a. Mormon towns in the region of the Colorado. Univ. of Utah Anthro. Papers No. 32. 26 pp.

______. 1958b. The activities of Jacob Hamblin in the region of the Colorado. Univ. Utah Anthr. Papers No. 42, Glen Canyon Ser. No. 9:1–137.

Danson, E. B. 1958. The Glen Canyon project. Plateau 30(3):75–78.

Darrah, W. C. 1947. Biographical sketches and original documents of the first Powell expedition of 1869, and the second Powell expedition of 1871–72. Utah Hist. Quarterly 15:9–153.

______. 1948. Beaman, Fennemore, Hillers, Dellenbough, Johnson, and Hottan (and) three letters by Andrew Hall. Utah Hist. Quarterly 16–17: 491–408.

______. 1951. Powell of the Colorado. Princeton University Press, Princeton, New Jersey. 426 pp.

Dellenbaugh, F. S. 1902. The romance of the Colorado River. G. P. Putnam's Sons, New York. 399 pp.

______. 1926. A canyon voyage, the narrative of the second Powell expedition down the Green-Colorado River from Wyoming, and the explorations on land, in the years 1871 and 1872. 2d edition. Yale Univ. Press. New Haven, Connecticut. 277 pp.

Dutton, C. E. 1880. Report of the geology of the high plateau of Utah, with atlas. U.S. Geographical and Geological Survey of the Rocky Mountain Region. Washington, D.C. Government Printing Office. 307 pp.

Freeman, L. R. 1923. The Colorado River yesterday, today and tomorrow. Dodd, Mead and Co., New York. 307 pp.

Freemont, J. C. 1846. Report of exploring expedition to the Rocky Mountains in the year 1842, and to Oregon and North California in the years 1843–44. Gales and Seaton Printers, Washington. 696 pp.

Gannett, H. 1900. A gazetteer of Utah. U.S. Geological Survey Bull. No. 166, 43 pp.

Gregory, H. E. 1917. Geology of the Navajo country. U.S. Geological Survey Prof. Paper No. 93. 161 pp.

______. 1938. The San Juan country: a geographic and geologic reconnaissance of southeastern Utah: U.S. Geological Survey Prof. Paper 188. 26 pp.

______. 1939. Diary of Almon Harris Thompson. Utah Hist. Quarterly 7:3–138.

______. 1945. Scientific explorations in southern Utah. Am. Journal of Sci. 243:527–549.

______. 1948. Geology and geography of central Kane County, Utah. Bull. Geol. Soc. of America 59:211–248.

______. 1949. Stephen Vandiver Jones, 1840–1920, and Journal April 21, 1871–Dec. 24, 1872. Utah Hist. Quarterly 16–17:11–174.

______. 1951. The geology and geography of the Paunsaugunt region, Utah, a survey of parts of Garfield and Kane Counties. U.S. Geol. Survey Prof. Paper No. 226. 116 pp.

Gregory, H. E., and R. C. Moore. 1931. The Kaiparowits region. U.S. Geological Survey Prof. Paper No. 164. 161 pp.

Gregory, H. E., W. C. Darrah, and C. Kelly, eds. 1948–49. Exploration of the Colorado River and the high plateaus of Utah in 1871–72. Utah Hist. Quarterly 16–17. 540 pp.

Hall, A. F. 1934. General report on the Rainbow Bridge-Monument Valley expedition 1933. Univ. of Calif. Press, Berkeley. 32 pp.

Hayward, L. C., D. E. Beck, and W. W. Tanner. 1958. Zoology of the upper Colorado River basin. 1. The biotic communities. Brigham Young University Biol. Surv. 1(3):1–74.

Heald, W. F. 1955. Who discovered Rainbow Bridge? Sierra Club Bulletin No. 40:22–28.

Hill, J. F. 1930. Spanish and Mexican exploration and trade northwest from New Mexico into the Great Basin, 1705–1853. Utah Hist. Quarterly 3:2–23.

Hite, C. 1939. Colorado River gold. From "Beaver Utonian," January 13, 1893. Utah Hist. Quarterly 7:139–140.

James, G. W. 1922. Utah, the land of blossoming valleys. Page Company, Boston. 371 pp.

Kelly, C. 1947. Captain Francis Marion Bishop's journal, August 15, 1870–June 3, 1872. Utah Hist. Quarterly 15:253–490.

______. 1949. Walter Clement Powell, and journal. April 21, 1871–December 7, 1872. Utah Hist. Quarterly 16–17: 253–490.

Kidder, A. V. 1910. Exploration in southwestern Utah in 1908. Am. J. of Archaeology 14(3):337–359.

Lawson, A. C. 1913. The gold in the Shinarump at Paria. Economic Geology 8:434–438.

Leavitt, F. J. 1943. Steam navigation on the Colorado River. Calif. Hist. Society Quarterly. 22(1–25), 151–174.

Miller, D. E. 1958. Discovery of Glen Canyon. Utah Hist. Quarterly 26:220–231.

______. 1959. Hole-in-the-Rock, an epic in the colonization of the Great American West. University of Utah Press, Salt Lake City, 229 pp.

Miser, H. D., K. W. Trimble, and S. Paige. The Rainbow Bridge, Utah. Geographical Review 13:518–531.

Parker, T. C. 1933. Game management problems of Utah national parks. Utah State Ag. College Misc. Publ. 10:32–34.

Poque, J. E. 1911. The great Rainbow Natural Bridge of southern Utah. Natl. Geogr. Mag. 22:1048–1056.

Powell, J. W. 1875. Exploration of the Colorado River of the West and its tributaries; explored in 1869 to 1872. Smithsonian Institution. Government Printing Office, Washington. 291 pp.

Presnall, C. C. 1933. Along nature's highways. Zion-Bryce Nat. Notes 6(6):52–57.

______. 1934. Animals and birds of Bryce Canyon National Park. Zion-Bryce Nat. Notes 6(6):52–57.

Pritchett, C. L. 1962. Vertebrate distribution in relation to certain habitats in central Kane County, Utah. Unpublished M.S. thesis, Dept. of Zoology, Brigham Young University, Provo, Utah. 83 pp.

Russell, R. W., and H. E. Thompson. 1964. A listing of common plants and vertebrate animals of Bryce Canyon National Park. Unpublished manuscript.

Schmeckebier, L. F. 1904. Catalogue and index of the publications of the Hayden, King, Powell, and Wheeler surveys. U.S. Geological Survey Bull. No. 222. 208 pp.

Tanner, V. W. 1940. A biotic study of the Kaiparowits region of Utah. Great Basin Nat. 1:97–126.

Tyler, S. L. 1951. Before Escalante, an early history of the Yuba Indians and the area north of New Mexico. Unpublished Ph.D. dissertation, Univ. of Utah. Salt Lake City. 231 pp.

Underhill, R. M. 1956. The Navajos. University of Oklahoma Press, Norman, Oklahoma. 292 pp.

Widtsoe, J. A. 1955. A journal of John A. Widtsoe Colorado River Party, September 3–19, 1922, preliminary to the Santa Fe Conference which framed the Colorado River Compact. Edited by A. R. Mortensen with a foreword by G. Homer Durham. Utah Hist. Quarterly 23:195–231.

Woodbury, A. M. 1950. A history of southern Utah and its national parks. 2d edition. Salt Lake City (reprinted from Utah State Historical Society Quarterly, July–Oct. 1944: Vol. 12:110–222).

Woodbury, A. M., S. Flowers, D. W. Lindsay, S. D. Durrant, N. K. Dean, A. W. Grundmann, J. R. Crook, W. H. Behle, H. G. Higgins, G. R. Smith, G. G. Muser, and D. B. McDonald. 1959. Ecological studies of the flora and fauna in Glen Canyon. Univ. of Utah Anthropol. Paper No. 40, Glen Canyon Ser. No. 7:1–225.

RANGE EXTENSION OF *ONYCHOMYS TORRIDUS LONGICAUDUS* (RODENTIA: CRICETIDAE) IN NORTHWESTERN NEVADA

Mark D. Engstrom[1] and Eugene D. Fleharty[1]

Abstract.— Two *Onychomys torridus longicaudus* Merriam were captured at a site 22 miles W Winnemucca, Humbolt Co., Nevada. This record extends the known range of *O. torridus* 165 km to the northeast.

The distribution of *Onychomys torridus* generally is restricted to the Lower Sonoran Life Zone of North America (Hall and Kelson, 1959, The Mammals of North America, Ronald Press, New York). However, there are a few records of *O. torridus* from the Upper Sonoran Life Zone along the eastern edge of the Sierra Nevada Mountains in northwestern and west-central Nevada (Hall, 1946, Mammals of Nevada, Univ. California Press, Berkeley, p. 495).

On 13 August 1964 a field party from the Museum of the High Plains, Fort Hays State University, under the direction of the second author, collected small mammals from a locale 22 miles W Winnemucca, Humbolt Co., in northwestern Nevada. The area was characterized by vegetation typical of the sandy, flat-floored valleys of the region. Dominant plant species, liberally spaced, included *Chrysothamnus* sp., *Atriplex* sp., and *Gutierrezia* sp., with local populations of *Artemisia tridentata*.

Subsequently, in conjunction with a forthcoming study on *Onychomys leucogaster*, examination of the specimens of that species housed in the Museum of the High Plains (MHP) revealed two specimens from the above site which actually pertain to the taxon *O. torridus longicaudus* Merriam. This record extends the known range of *O. torridus* 165 km to the northeast of the northernmost locality reported by Hall (1946: 495) which was a site 3 miles NNE Toulon, 3900 ft, in southern Pershing Co., Nevada.

Of the two specimens, one (MHP 3998) is an adult male (Age Class V, Van Cura and Hoffmeister, 1966, J. Mamm. 47:613–630), whereas the other (MHP 4446) is a subadult female molting into adult pelage (Age Class II, Van Cura and Hoffmeister 1966). Selected measurements (in millimeters unless otherwise noted) of the two (adult, subadult), with mean values for *O. t. longicaudus* reported by Hall (1946) in parentheses, are as follows: total length 139, 144 (138); length of tail 43, 44 (46.5); length of hind foot 20, 18 (19.3); weight (in grams) 21.8, 19.5 (22.6); greatest length of skull 25.0, 23.7 (24.9); breadth of braincase 11.4, 19.8 (11.3); length of nasals 9.5, 8.6 (9.3); shelf of bony palate 4.4, 4.2 (4.4); alveolar length of maxillary toothrow 3.7, 3.6 (3.8).

The remaining collection of small mammals from Humbolt County contained an unusual variety of heteromyid rodents, probably due to an admixture of Lower (*Dipodomys deserti* and *D. merriami*) and Upper Sonoran faunal elements. Species and numbers collected were: *D. deserti*, 6; *D. merriami*, 15; *D. microps*, 1; *D. ordii*, 7; *Microdipodops megacephalus*, 5; *Perognathus longimembris*, 1; and *P. parvus*, 2. Additionally, three specimens of *Ammospermophilus leucurus* were taken.

The authors thank Jerry R. Choate and Robert C. Dowler (Fort Hays State University) for critically reviewing this manuscript.

---

[1] Museum of the High Plains, Fort Hays State University, Hays, Kansas 67601.

THE REPRODUCTIVE ECOLOGY OF THE TAHOE SUCKER, *CATOSTOMUS TAHOENSIS*, IN PYRAMID LAKE, NEVADA

Joseph L. Kennedy[1] and Paul A. Kucera[1]

Abstract.— The Tahoe sucker spawns in Pyramid Lake from April to August at lake temperatures of 11.7 to 22.7 C. The spawning population is comprised of a large lake spawning group and a numerically smaller river running group. The river running group is smaller in length and was not considered during this study.

The sex ratio of sampled suckers significantly favored the females. This is the result of the longer life of females and greater mortality of males during spawning.

Pyramid Lake Tahoe suckers reach sexual maturity at two to three years of age; however, those in Lake Tahoe do not mature until four or five years of age. The size at sexual maturity is different in both populations, which suggests that size or rate of growth rather than age determines sexual maturity.

The fecundity of Tahoe suckers is positively correlated with fork length, weight, and age. Additional analysis showed that a better correlation occurred between fish size (either length or net weight) and total ovary weight. We believe that fish size is primarily correlated with total reproductive tissue produced and secondarily with fecundity. A comparison of the Pyramid Lake population and the Lake Tahoe population demonstrated that size, not age, is the most important determinant of Tahoe sucker fecundity.

The Tahoe sucker, *Catostomus tahoensis*, is found in the Lahontan drainage system of western Nevada and eastern California. Within the Truckee River system, it comprises a major portion of the fish population (LaRivers 1962). It is of little direct economic value, but it does provide a significant food source for trout in Pyramid Lake and Lake Tahoe (Miller 1951) and probably contributes to the food of brown trout in the Truckee River. Its current status in rapidly desiccating Walker Lake is unknown.

Although *C. tahoensis* is one of the most common fishes of the Lahontan drainage, very little is known about its reproductive ecology. Snyder (1917) gave a brief description of spawning behavior, and Willsrud (1966) presented fairly extensive data on the reproductive biology of the Tahoe suckers in Lake Tahoe. The objectives of our study were to describe the reproductive ecology of the Tahoe sucker in Pyramid Lake and to compare it with other species of suckers. Special emphasis was given to comparisons between the Lake Tahoe population (Willsrud 1966) and the Pyramid Lake population.

Methods

Tahoe suckers were collected monthly from November 1975 through March 1977 through the use of bottom-set 1.83 × 76.2 m variable mesh gill nets. These were comprised of ten 7.6 m panels of 12.7, 19.05, 25.4, 31.75, 38.1, 44.45, 50.4, 63.5, 76.2, and 88.9 mm bar mesh netting. Fyke nets constructed of 12.7 mm mesh netting over 1.22 m diameter hoops were also used. The net was 4.8 m long, with a 15.24 m lead.

Sex ratios were obtained from a monthly subsample of the Tahoe suckers collected. During the spawning season, secondary sexual characters were used after verification by internal examination.

Ovaries were removed from 53 freshly killed Tahoe suckers for fecundity determination. Each ovary was weighed to the nearest 0.001 gram, and ten ova diameters were measured to the nearest 0.1 mm. The fork length of each fish was measured to the nearest mm, and each fish was weighed to the nearest gram. Scales were also taken for age determination.

Three replicate subsamples of approximately one gram of eggs were taken from each ovary, weighed to the nearest 0.001 gram, and preserved for later counting. Fecundity was then estimated by direct proportion per ovary.

---

[1] W. F. Sigler & Associates Inc., 1005 Terminal Way, Suite 155, Reno, Nevada 89502.

Linear and nonlinear ($\log_{10}$) regressions were used to examine the interrelationships between fecundity, egg size, body weight, fork length (FL), and age. The analyses that involved fish weight used net weight; that is, body weight minus ovary weight.

Results and Discussion

Reproductive Cycle.— Nuptial tubercles first appeared on males in December and by January were very pronounced, forming definite rows along the rays of the anal and caudal fin. The females usually had no tubercles, but a few had them on the anal fin. The females exhibited a characteristic distended vent. Mature males were collected through the spring and summer and as late as September.

During March and April 1976, an estimated 5500 Tahoe suckers ascended the Marble Bluff fishway or the Truckee River to spawn. The river spawning run of Tahoe suckers occurred when the mean lake surface temperature was 10 C, and the water temperature in the river 9 to 12 C. This corresponded to earlier observations on Pyramid Lake (LaRivers 1962). LaRivers (1962) further reported that *C. tahoensis* ascending the Truckee River from Pyramid Lake were all small (< 305 mm) which our data also support. Geen et al. (1966) found that spawning migrations of longnose suckers (*Catostomus catostomus*) began at 10 C and peaked at 12.3 C, and those of white suckers (*Catostomus commersoni*) peaked at 13.5 C. Spawning runs of *C. catostomus*, from western Lake Superior, peaked at 13 C over a seven-year period (Bailey 1969). Willsrud (1966) noted separate river and lake spawning populations of Tahoe suckers in Lake Tahoe, California-Nevada, which suggests they may be genetically different strains. The Utah sucker (*Catostomus ardens*) also exhibits river and lake spawning populations in Bear Lake, Utah-Idaho (McConnell et al. 1957). Preliminary electrophoretic tissue analysis on *C. ardens* from Bear Lake indicates no significant difference between the two groups (Klar, unpublished data).

The river spawning run coincided with the peak of the gonadal somatic index (14 percent) of the suckers collected in the lake. The GSI of the lake spawning fish (Fig. 1) remained high in April and May, and 95.4 percent of the fish collected in June were sexually mature. This decreased to 85.7 percent in July and to only 5.8 percent in August (August GSI = 1.5 percent). Catch rates reveal that general activity patterns decrease over the spring to a low point in July and August (Fig. 1). In July spent fish were stressed and inactive; therefore, we sampled a higher percent but actually lower numbers of ripe fish, which is reflected in reduced catch rates. As Tahoe sucker activity patterns are associated with spawning behavior (Vigg, unpublished data), we believe the GSIs and percent ripe fish, in this case, represent biased results. Thus, lake spawning activity commenced in April and was essentially completed by July, at water temperatures of 11.7–22.7 C.

The protracted spawning period, from April to August, that we observed for *C. tahoensis* has also been found for *C. discobolus* (Andreasen and Barnes 1975) and by Willsrud (1966) for Tahoe suckers in Lake Tahoe. Spawning activity in Pyramid Lake commences as both water temperature and photoperiod begin to increase and is drawn out over a period of several months. Andreasen and Barnes (1975) speculated that both water temperature and photoperiod combine to trigger spawning activity, but Kaya and Hasler (1972) reported that fishery scientists found a heterogeneity of responses to experimental conditions with different species. Changes in water temperature and photoperiod are so closely linked in Pyramid Lake that determining the relative importance of either to initiation of spawning may be impossible without controlled experiments.

Sex Ratio.— Of 1,557 Tahoe suckers sexed from November 1975 through February 1977, 740 were males and 817 were females. This ratio, 1:1.10, significantly differs from the expected 1:1 ratio ($P<0.05$). The larger number of females in the population is attributable to the longer life of females and greater mortality of males. Age and growth studies have shown that females in Pyramid Lake live to age five, but no males have been collected that were older than four (Robertson, unpublished data). A similar occurrence has been noted in white suckers (Geen et al. 1966, Scott and Crossman 1973). Willsrud (1966) noted a greater decrease in growth rate and a proportionately greater decrease in the number of males in older size groups in Lake Tahoe. Male suckers exhibit reproductive activity for a greater portion of the year in Pyramid Lake and Lake Tahoe and tend to remain in the spawning areas for a greater time span than the females. This may result in higher mortality for males from either stress or predation.

SEXUAL MATURITY.— The majority of the male suckers mature at two years of age, and all are mature by age three. A few of the females are mature at two, and the majority mature at three (Table 1). Most individuals were from 212 to 324 mm long at the onset of sexual maturity. Willsrud (1966) reported that Tahoe suckers in Lake Tahoe mature at lengths of 147 to 200 mm and at

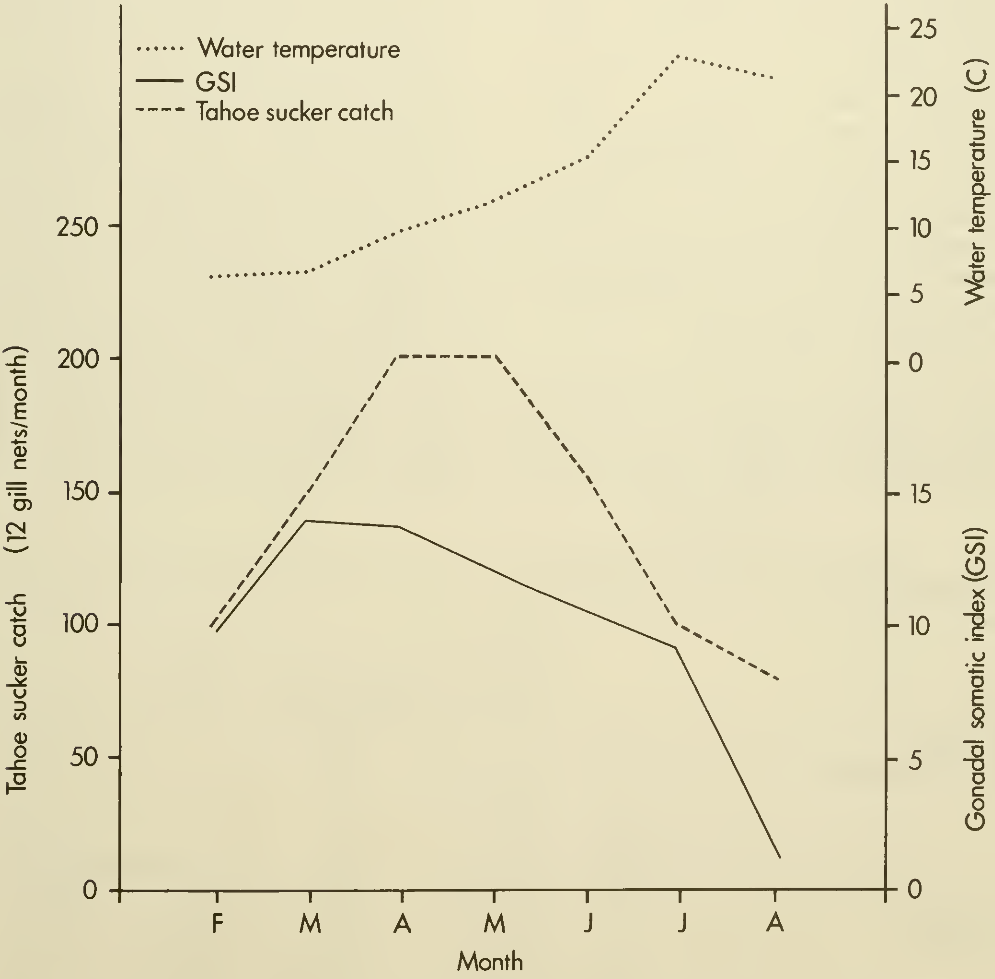


Fig. 1. Monthly changes in Tahoe sucker catches and gonadal somatic indexes in Pyramid Lake in 1976. Water temperatures are the monthly surface averages.

four or five years of age. These data show that both size and age influence sexual maturity. Since Pyramid Lake suckers reach sexual maturity at a much younger age (and larger size), size seems more important than age in determining the onset of sexual maturity.

EGG SIZE.— The mature egg diameter for Tahoe suckers varied from 1.5 to 2 mm ($\bar{x}=1.8$). Willsrud (1966) reported similar egg size for the Tahoe suckers from Lake Tahoe (Table 1), and Andreasen and Barnes (1975) reported mature ovum diameters of approximately 2 mm for *C. ardens* and *C. discobolus.* Lack (1948) proposed the existence of an egg size/fecundity relationship that stabilized the average fecundity of the population through a differential survival rate for different size fry. This is supported by Dahl (1918–19, cited by Bagenal 1971) and Gray (1926, 1928, cited in Bagenal 1971), who showed that larger eggs produce larger fry. However, we did not find a significant relationship between ovum diameter and age or fecundity ($F=3.67$ and 1.80, respectively). Either our sample size was inadequate or some other mechanism exists that maintains a stable average fecundity in the Pyramid Lake population.

FECUNDITY.— The mean fecundity of Tahoe suckers from Pyramid Lake was 20,550 eggs per female. This is less than was found for *C. ardens* and is roughly comparable to *C. discobolus* (Andreasen and Barnes 1975). The mean fecundity of the larger *C. catostomus* was 26,000 (Bailey 1969), but the fecundity of fish of the same size was greater for Tahoe suckers. The white (*C. commersoni*) had more eggs per female in all size groups than Tahoe suckers (Vessel and Eddy 1941). The $\log_{10}$ regression for number of eggs produced by a female Tahoe sucker is significantly related to age ($F=47.87$, $P<0.05$) fork length ($F=107.52$, $P<0.05$), and net weight ($F=86.99$, $P<0.05$). There is much disagreement concerning the relative importance of each of these variables to the fecundity of fish. The size of the fish, length and weight, determines the amount of energy that can be expended for the production of reproductive tissue, and space available within the body cavity. From a practical point of view, it matters little whether weight or length is used as a predictor variable of fecundity. For Tahoe suckers, both length and net weight are highly correlated with fecundity ($r=.79$ and .82, respectively, $P<0.05$). In both cases the relationship had a significant linear fit but was best described by a $\log_{10}$ equation. A reexamination of Willsrud's data (1966) showed a similar high correlation between fecundity and fork length ($r=.92$, $P<0.05$). He did not present his data in a manner that will allow an analysis of the weight-fecundity relationship. An analysis of the relationship between fork length and weight and ovary weight of

TABLE 1. Comparison of Lake Tahoe suckers from Lake Tahoe, California-Nevada (eggs numbers estimated from log equation) and Pyramid Lake, Nevada.

Location	Age	$\bar{x}$ Fork Length (mm)	$\bar{x}$ Total Weight (grams)	$\bar{x}$ Ovum Diameter (mm)	$\bar{x}$ Fecundity
Lake Tahoe (from Willsrud 1966)	IV	147	45		2,510
	V	170	72		3,502
	VI	201	118		5,164
	VII	229	172	1.90	7,204
	VIII	249	222		8,995
	IX	277	304		11,230
	X	310	426		14,822
	>X	363	680		21,857
Pyramid Lake	II	291	304	1.88	13,213
	III	330	453	1.87	19,000
	IV	360	590	1.80	26,229
	V	433	998	1.77	59,268

Pyramid Lake Tahoe suckers showed that length and weight are highly correlated with ovary weight. In fact, the r values were higher than those for fecundity (r = .85 and .79, respectively). This further supports our belief that fish size is directly related to the total amount of reproductive tissue that can be produced under a given set of environmental conditions. Fecundity in turn is related to the total ovary weight and ovum size as was shown by Kucera and Kennedy (1977).

The interrelationships of fish size (length and weight) and age and fecundity for Tahoe suckers are more difficult to analyze. The Lake Tahoe population has radically different growth rates and age structure. For example, the oldest sucker we have collected was 5 years old, and Willsrud collected several that were 15 years of age. The length-weight relationship for both populations is similar.

A one-way analysis of covariance demonstrated that the slopes of the fork length-fecundity relationships are significantly different ($F = 9.04$, $P < 0.05$). We feel this is due to differences in the growth rate. Examination of these relationships (Fig. 2)

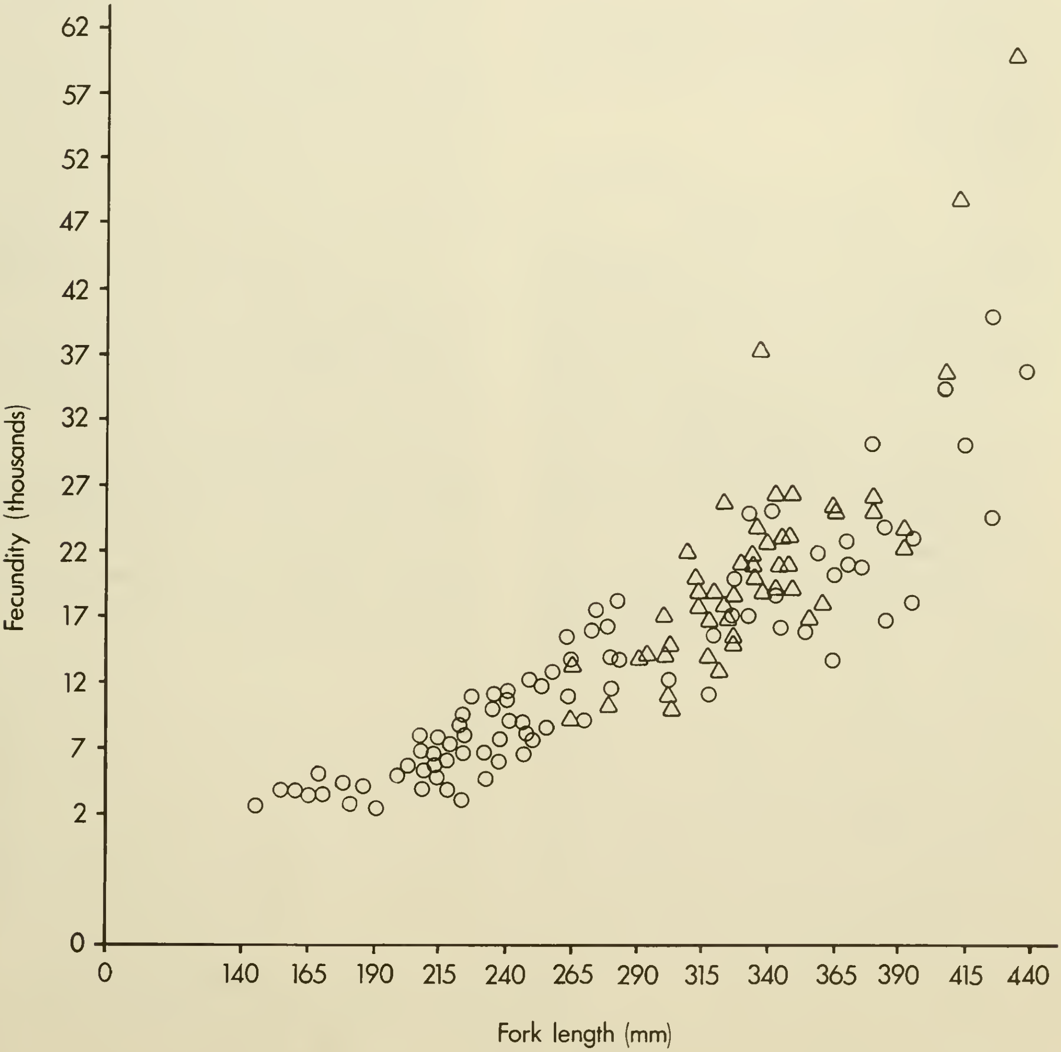


Fig. 2. Comparison of Tahoe sucker fecundities from Pyramid Lake (Δ) and Lake Tahoe (0).

shows there is significant overlap. Furthermore, comparison of mean fecundities over similar ranges in fork length (265 to 440 mm) by a one-way analysis of variance indicates no significant differences in the means ($F = 1.63$, $P > 0.05$). Comparison of the mean fecundity for a given weight fish from either population shows close agreement (Table 1). This leads us to believe that Tahoe sucker fecundity is related to size and that age is a secondary influence.

ACKNOWLEDGMENTS

We wish to thank the entire crew of W. F. Sigler & Associates Inc., especially Mr. Steven Vigg (distribution and abundance data) and Mrs. Denise Robertson (age and growth data).

LITERATURE CITED

ANDREASEN, J. K., AND J. R. BARNES. 1975. Reproductive life history of *Catostomus ardens* and *C. discobolus* in the Weber River, Utah. Copeia 1975(4):643–648.

BAGENAL, T. B. 1971. A short review of fish fecundity, p.89–111. *In*: S. B. Gerking (ed.), The biological basis of freshwater fish production. Blackwell Sci. Publ., Oxford and Edinburgh.

BAILEY, M. M. 1969. Age, growth, and maturity of the longnose sucker *Catostomus catostomus* of Western Lake Superior. J. Fish. Res. Bd. Canada 26(5):1289–1299.

DAHL, K. 1918–19. Studies of trout and trout waters in Norway. Salm. Trout Mag. 17:58–79;18:16–33. (Cited in Bagenal 1971).

GEEN, G. H., T. G. NORTHCOTE, G. F. HARTMAN, AND C. C. LINDSEY. 1966. Life histories of two species of catostomid fishes in Sixteenmile Lake, British Columbia, with particular reference to inlet stream spawning. J. Fish Res. Bd. Canada 23(11):1761–1788.

GRAY, J. 1926. The growth of fish: I. The relationship between embryo and yolk in *Salmo fario*. Br. J. Exp. Biol. 4:215–225. (Cited in Bagenal 1971).

———. 1928. The growth of fish: II. The growth rate of the embryo of *Salmo fario*. Br. J. Exp. Biol. 6:110–124. (Cited in Bagenal 1971).

KAYA, C. M., AND A. D. HASLER. 1972. Photoperiod and temperature effects on the gonads of green sunfish, *Lepomis cyanellus* (Rafinesque), during the quiescent winter phase of its annual sexual cycle. Trans. Amer. Fish. Soc. 101(2):270–275.

KUCERA, P. A., AND J. L. KENNEDY. 1977. Evaluation of a sphere volume method for estimating fish fecundity. Prog. Fish-Cult. 39(3):115–117.

LACK, D. 1948. The significance of litter size. J. Anim. Ecol. 17:45–50.

LARIVERS, I. 1962. Fishes and fisheries of Nevada. Nevada State Fish and Game Comm. 782 p.

MILLER, R. G. 1951. The natural history of Lake Tahoe fishes. Ph.D. dissertation. Stanford Univ. 160 p.

MCCONNELL, W. J., W. J. CLARK, AND W. F. SIGLER. 1957. Bear Lake: its fish and fishing. Utah State Dept. of Fish and Game, Idaho Dept. of Fish and Game, Wildlife Manage. Dept. of Utah State Agri. Coll. 76 p.

SCOTT, W. B., AND E. J. CROSSMAN. 1973. Freshwater fishes of Canada. Fish. Res. Bd. of Canada Bull. 184:538–543.

SNYDER, J. O. 1917. The fishes of the Lahontan system of Nevada and northeastern California. U.S. Bur. Fish. Bull. 1915–16(35):31–86.

VESSEL, M. F., AND S. EDDY. 1941. A preliminary study of the egg production of certain Minnesota fishes. Fish. Res. Rep. 26. Minnesota Dept. of Cons. Div. of Game and Fish. 26 p.

WILLSRUD, T. 1966. A study of the Tahoe sucker *Castostomus tahoensis* Gill and Jordan. M.A. thesis. San Jose State Coll. 96 p.

PRIMARY PRODUCTIVITY IN MEROMICTIC BIG SODA LAKE, NEVADA

R. P. Axler[1], R. M. Gersberg[1],
and L. J. Paulson[2]

Abstract.— *In situ* radiocarbon uptake measurements conducted at Big Soda Lake, Nevada, indicate that (i) bacterial photosynthesis comprises an important fraction (30 percent) of the lake's total primary production and (ii) bacterial chemosynthesis contributes significantly to organic particle production. The results of nutrient enrichment bioassay experiments support Hutchinson's prediction that availability of inorganic nitrogen, rather than phosphorus, limits primary production in the mixolimnion. Nutrient additions of NO_3–N with Fe^{+3} most stimulated ^{14}C uptake.

Big Soda Lake was described hydrologically as early as 1885 (Russell 1885) and has received considerable limnological attention by virtue of its meromixis (Hutchinson 1937, 1957, Kimmel et al., in press). However, little biological data has been accumulated on the lake. Hutchinson, in 1933, found a thermally stratified mixolimnion with an oxygen depleted hypolimnion, overlying an anoxic monimolimnion. He measured concentrations of a number of nutrients and deduced that phosphorus was much less likely to limit primary production in the mixolimnion than inorganic combined nitrogen (Hutchinson 1937). Koenig et al. (1971) reported on the limnological status of the lake and noted a stratum of pink-colored water located in the deep hypolimnion. Photosynthetic purple sulfur bacteria were identified in this water (*Rhodothece sp.* and *Thiothece sp.*). However, primary productivity measurements were not made.

In a meromictic lake with high concentrations of sulfide in the chemocline region and an anoxic (but photic) hypolimnion, bacterial photosynthesis may comprise a significant fraction of a lake's primary production (Wetzel 1975, Cohen et al. 1977a, b). We have utilized inorganic 14 C to estimate the magnitude of algal and bacterial photosynthesis at Big Soda Lake and have conducted nutrient enrichment experiments to investigate the possible nitrogen limitation suggested by Hutchinson.

Methods

Temperature, pH, and dissolved oxygen were measured *in situ* with a calibrated Hydrolab water quality analyzer. Light penetration was measured with a Whitney LMD photometer. Total alkalinity was determined by potentiometric titration with 0.1N HCl. Chloride concentrations were determined by the argentometric method (Am. Public Health Assoc. 1971). Total phosphorus, reactive iron, and nitrate were determined by the methods of Strickland and Parsons (1968) as modified by Fujita (see Goldman 1974). Ammonia was determined as per Solórzano (1969) as modified by Liddicoat et al. (1975). *In situ* incubations of water samples with ^{14}C for determination of primary productivity and nutrient stimulation followed the procedures developed and modified by Goldman (1963). Filtered samples were acid fumed (Wetzel 1965) to remove precipitated and adsorbed ^{14}C. Solar insolation was recorded with a Belfort pyrheliometer. Dissolved inorganic carbon (DIC) available for photosynthesis was approximated from temperature, pH, and alkalinity data using the data of Saunders et al. (1962). This method probably over-estimates available DIC in alkaline Big Soda Lake samples (see Hutchinson 1957, Talling 1973), and thereby results in some overestimation of primary productivity.

---

[1] Division of Environmental Studies, University of California, Davis, California 95616.

[2] Department of Biological Sciences, University of Nevada, Las Vegas, Nevada 89154.

Results and Discussion

On 23 April 1977 the thermocline and chemocline were located at about 5 m and 37.5 m, respectively (Fig. 1). The vertical extinction coefficient was 0.35 m^{-1} and measurable light penetrated to 26 m.

The vertical distribution of primary productivity (Fig. 2) was bimodal with peaks at 5 and 25 m. The zone below 17.5 m was oxygen deficient (<1 mg $0_2 \cdot l^{-1}$) and presumably, could only support photosynthetic growth by anaerobic bacteria.[3] The areal productivity for this zone was calculated to be 317 mg $C \cdot m^{-2} \cdot day^{-1}$. Similar calculations for the upper, aerobic zone yielded a value of 717 mg $C \cdot m^{-2} \cdot day^{-1}$ (phytoplankton photosynthesis). Therefore, the bacterial contribution to the total photosynthetic productivity in the water column was 31 percent.

At all depths inorganic carbon uptake in dark bottles represents a large percentage of that in light bottles, thus indicating sig-

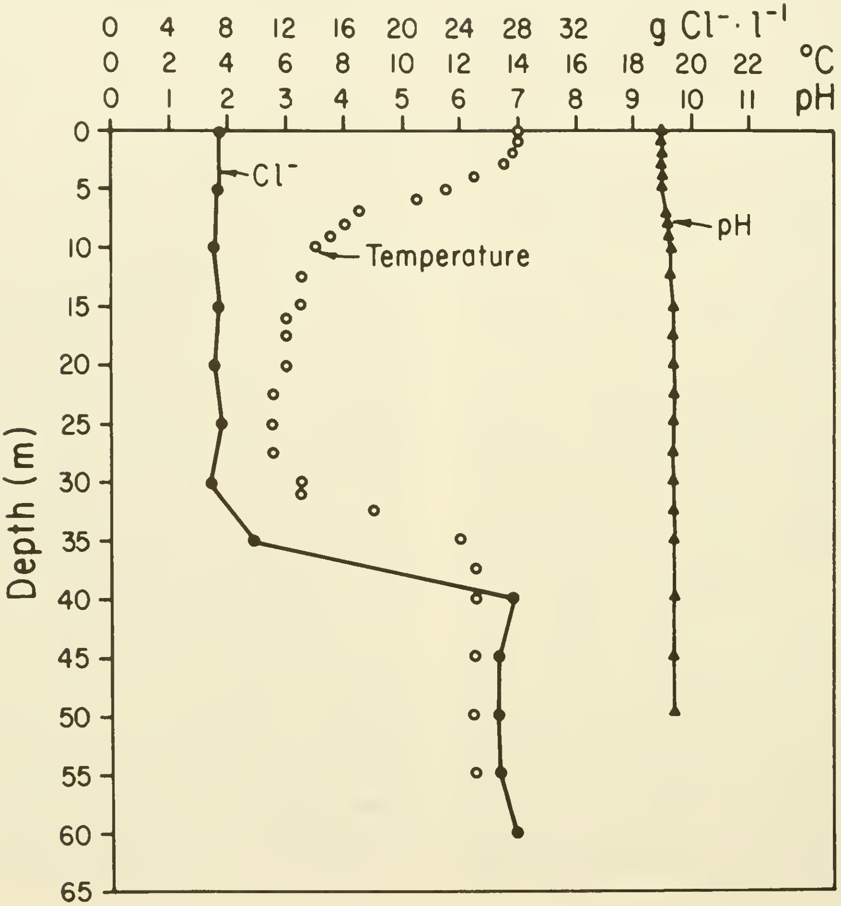


Fig. 1. Depth profiles of temperature, pH, and chloride for Big Soda Lake, 23 April 1977.

---

[3] Recent evidence indicates that some species of *Oscillatoria* are able to photosynthesize anaerobically by using H_2S as a source of electrons for photosystem II (Cohen et al. 1975).

nificant chemosynthetic activity. In the mixolimnion this is probably due to both nitrifying bacteria (which utilize electrons from NH_4^+ to reduce CO_2) and sulfur oxidizing bacteria (which utilize electrons from H_2S to reduce CO_2). Concentrations of sulfide (from Koenig et al. 1971) and ammonia (Fig. 3) in the region of the chemocline are 400 mg $S \cdot \ell^{-1}$ and 4–34 mg $N \cdot \ell^{-1}$, respectively, and therefore, the gradual entrainment of monimolimnetic water (see Kimmel et al., in press) must introduce appreciable quantities of these nutrients into the mixolimnion during the fall-winter overturn. Conditions in the deep hypolimnion are also suitable for chemosynthetic denitrifying sulfur bacteria, such as *Thiobacillus denitrificans.* The concentration of nitrate in the oxygen depleted hypolimnion does decline from 55 to 9 $\mu gN \cdot \ell^{-1}$ (see Fig. 3). In the strictly anoxic monimolimnion, high dark uptake rates may be due to the presence of anaerobic sulfate reducing bacteria (e.g., *Delsulfovibrio desulfuricans*) which are facultatively autotrophic and use molecular hydrogen as an electron donor (Doelle 1975).

Our data for total phosphorus, ammonia, and iron (Fig. 3) are similar to those reported by Hutchinson (1937). A series of nutrient enrichment experiments on epilimnetic water collected on 24 April 1976 provided evidence to support Hutchinson's suggestions concerning phosphorus and nitrogen limitation of primary productivity. Maximum stimulation of ^{14}C uptake occurred in water samples enriched with both nitrate and iron (Fig. 4). Phosphate additions, either singly or together with nitrate or iron,

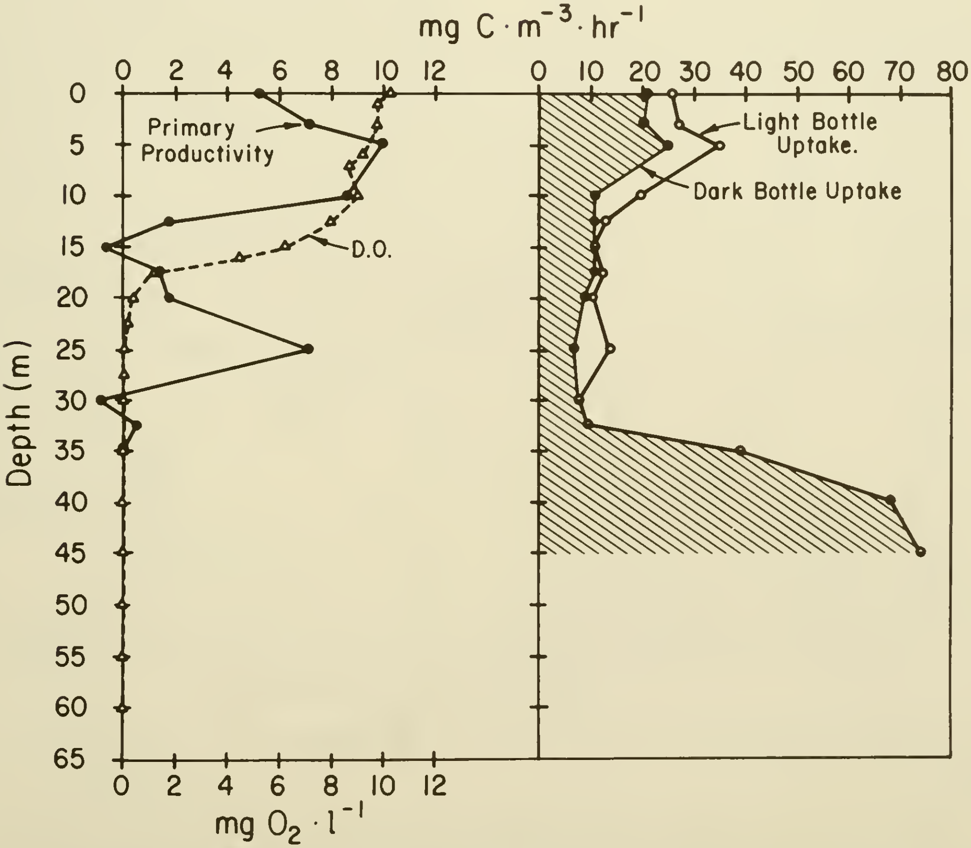


Fig 2. Depth profiles of dissolved oxygen and primary productivity, 23 April 1977 (1000–1400 hrs). Productivity data represents the difference in uptake between light and dark sample bottles where each has been corrected for dark-uptake during the time between removal from the lake and filtration.

produced a small effect. Similarly, trace metal additions provided little stimulation unless added in concert with nitrate and iron.[4]

Primary production in many types of lakes has been shown to be limited by inorganic nitrogen concentration and, in a number of hardwater calcareous lakes, by available iron (Wetzel 1975). Goldman (1972) reported that on water samples from Lake Tahoe, California, nitrate and iron acting in concert produced a greater stimulation of primary productivity than either one added singly. Such an effect may be due to the role of iron in the assimilatory reduction of nitrate by microorganisms. After reduction to nitrite via the enzyme nitrate reductase, further reduction to ammonium is catalyzed by nitrite reductase. Iron appears to be an integral component of both nitrite reductase and of ferredoxin, the immediate electron donor (Morris 1975, Healey 1973).

The data we have accumulated on Big Soda Lake are of a preliminary nature and certainly insufficient to fully delineate the microbial processes occurring in the water column. However, they do indicate a very

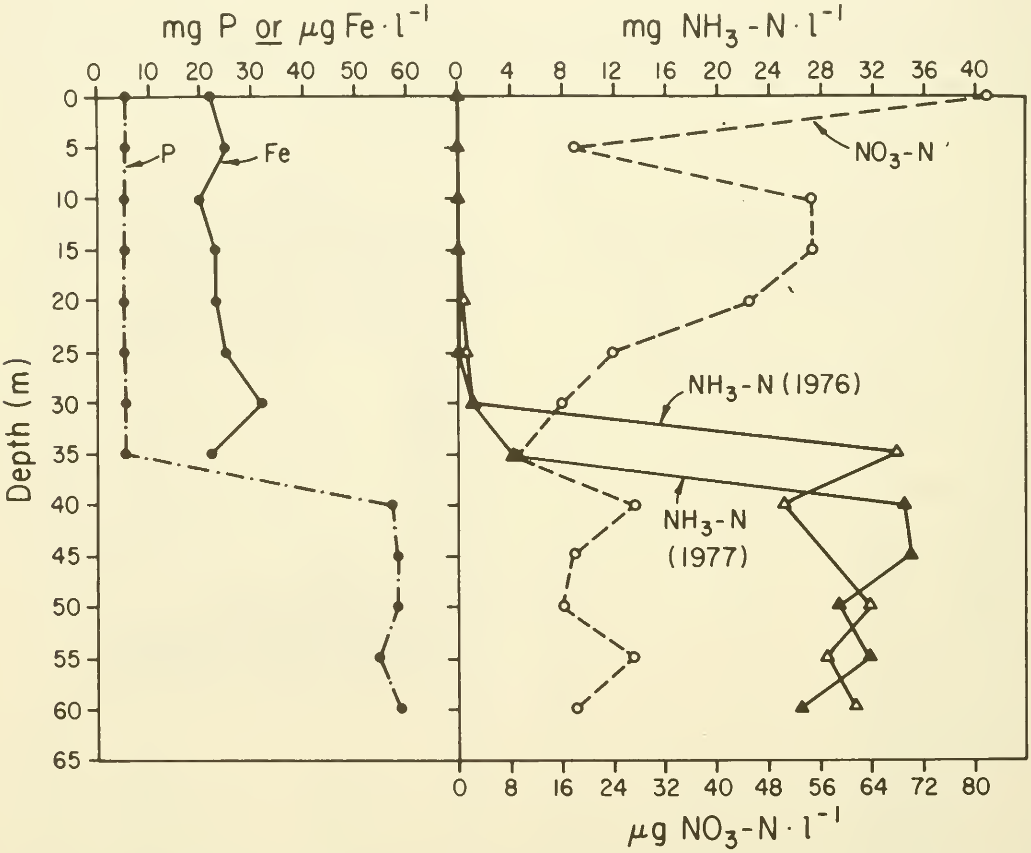


Fig. 3. Depth profiles of NO_3-N and NH_3-N (24 April 1977); total phosphorus, reactive iron, and NH_3-N (24 April 1976).

---

[4] Unfortunately, the variance in our primary productivity data from April 1976 was generally too high to include in this report (presumably this was due to precipitation of carbonates during the sample filtrations with subsequent clogging of the filtration apparatus). However, the limnological condition of the lake, as determined by vertical profiles of temperature, dissolved oxygen, light attenuation, alkalinity, pH, and chloride and ammonium concentrations was virtually identical in 1976 to 1977. Furthermore, the primary productivity at 0 m and 5 m (23 April 1976) was 4.5 mg $C \cdot m^{-3} \cdot hr^{-1}$ and 9.3 mg $C \cdot m^{-3} \cdot hr^{-1}$, respectively, which were similar to the rates measured at these depths in 1977.

interesting system in which bacterial photosynthesis is an important fraction of the total primary productivity, and bacterial chemosynthesis contributes significantly to organic particle production. There was no obvious pink color in deep hypolimnetic water when our measurements were made and, therefore, one might expect the rate of bacterial photosynthesis to be much higher later in the growing season (as when Koenig et al. collected samples in October 1970). However, the fraction of total primary productivity contributed by the sulfur bacteria seasonally remains to be investigated.

We are especially indebted to Dr. Bruce L. Kimmel from the University of Oklahoma Biological Station, who helped with the field and laboratory work and data analysis and interpretation, and who critically reviewed the manuscript. We acknowledge the field and laboratory assistance of the University of California (Davis) 1976 and 1977 limnology laboratory classes and the financial assistance of the Division of Environmental Studies. Some of the equipment used in this investigation was purchased under the auspices of National Science Foundation grants NSF BM 74-02246 A01 and NSF DEB 76-19524 to C. R. Goldman. J. Coil contributed significantly with the laboratory analyses. M. Smith and G. Malyj aided in manuscript preparation.

LITERATURE CITED

AMERICAN PUBLIC HEALTH ASSOCIATION. 1971. Standard methods for the examination of water and wastewater. New York. 874 pp.

COHEN, Y., B. B. JORGENSEN, E. PADAN, AND M. SHILO. 1975. Sulfide dependent anoxygenic photosynthesis in the cyanobacterium *Oscillatoria limnetic.* Nature 257:489–492.

COHEN, Y., W. E. KRUMBEIN, AND M. SHILO. 1977a. Solar Lake (Sinai). 2. Distribution of photosynthetic microorganisms and primary production. Limnol. Oceanogr. 22:609–620.

———. 1977b. Solar Lake (Sinai). 3. Bacterial distribution and production. Limnol. Oceanogr. 22:621–634.

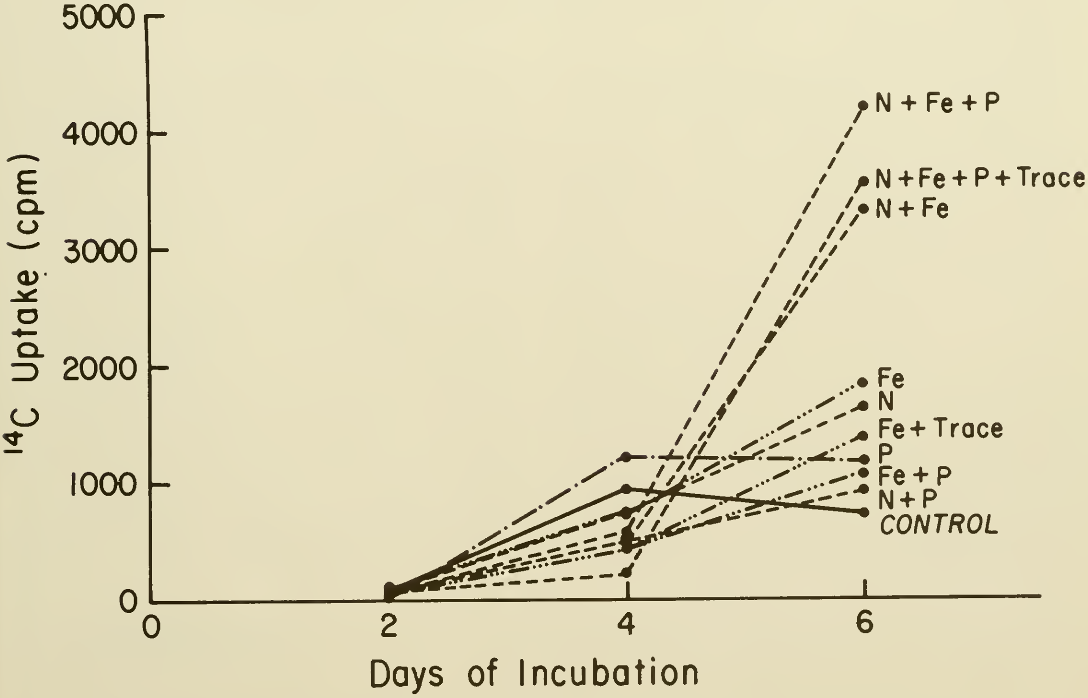


Fig. 4. Results of nutrient enrichment bioassays on water collected 24 April 1976. Enrichment concentrations were: N = 50 μg NO_3^--$N \cdot l^{-1}$; P = 50 μg PO_4^{-3}–$P \cdot l^{-1}$; Fe = 25 μg $Fe^{+3} l^{-1}$; Trace = 3 $\mu g \cdot l^{-1}$ each of Co, Mo, Zn, Mn.

Doelle, H. W. 1975. Bacterial metabolism. New York: Academic Press. 738 pp.

Goldman, C. R. 1963. The measurement of primary productivity and limiting factors in freshwater with carbon-14, p. 103–113. *In*: M. S. Doty (ed.), Proc. Conference on Primary Productivity Measurement, Marine and Freshwater. U.S.A.E.C., Div. Tech. Inform. Rep. TID-7633.

______. 1972. The role of minor nutrients in limiting the productivity of aquatic systems, pp. 21–38. *In*: G. E. Likens (ed.), Nutrients and eutrophication. Amer. Soc. Limnol. Oceanogr. Spec. Symp. No. 1.

______. 1974. Eutrophication of Lake Tahoe emphasizing water quality. EPA-660/3-74-03. U.S. Gov. Printing Office, Washington, D.C. 408 pp.

Healey, F. P. 1973. Inorganic nutrient uptake and deficiency in algae. C.R.C. Crit. Rev. in Microb. 3:69–113.

Hutchinson, G. E. 1937. A contribution to the limnology of arid regions. Trans. Conn. Acad. Sci. 33:1–132.

______. 1957. A treatise on limnology. I. Geography, physics, and chemistry. New York: John Wiley. 1015 pp.

Kimmel, B. L., R. M. Gersberg, L. J. Paulson, R. P. Axler, and C. R. Goldman. In press. Recent changes in the meromictic status of Big Soda Lake, Nevada. Limnol. Oceanogr.

Koenig, E. R., J. R. Baker, L. J. Paulson, and R. W. Tew. 1971. Limnological status of Big Soda Lake, Nevada, October 1970. Great Basin Nat. 31:107–108.

Liddicoat, M. I., S. Tibbits, and E. I. Butler. 1975. The determination of ammonia in seawater. Limnol. Oceanogr. 20:131–132.

Morris, I. 1975. Nitrogen assimilation and protein synthesis. *In*: W. D. P. Stewart (ed.), Algal physiology and biochemistry. Univ. of Calif. Press., Berkeley.

Russell, I. C. 1885. Geological history of Lake Lahontan. U.S. Geol. Surv. Monogr. 11, 287 pp.

Saunders, G. W., F. B. Trama, and R. W. Bachmann. 1962. Evaluation of a modified C-14 technique for shipboard estimation of photosynthesis in large lakes. Great Lakes Div., Univ. of Mich., Ann Arbor, Publ. 8, 1–61.

Solórzano, L. 1969. Determination of ammonia in natural waters by the phenolhypochlorite method. Limnol. Oceanogr. 14:799–801.

Strickland, J. D. H. and T. R. Parsons. 1968. A practical handbook of seawater analysis. Bull. Fish. Res. Board Can. No. 167. 311 pp.

Talling, J. F. 1973. The application of some electrochemical methods to the measurement of photosynthesis and respiration in freshwaters. Freshwater Biol. 3:335–362.

Wetzel, R. G. 1965. Necessity for decontamination of filters in C-14 measured rates of photosynthesis in freshwaters. Ecology 46:540–542.

______. 1975. Limnology. W. B. Saunders, Phila. 743 pp.

CURRENT STATUS OF CUTTHROAT TROUT SUBSPECIES IN THE WESTERN BONNEVILLE BASIN

Terry J. Hickman[1] and Donald A. Duff[2]

ABSTRACT.— Recent discoveries of native cutthroat trout populations in desert mountain ranges on the western fringe of the Bonneville Basin have prompted intensified management efforts by state and federal agencies. Analysis of Snake Valley cutthroat specimens in Trout Creek, Deep Creek Mountain Range, Utah, indicate this is a pure strain of the trout which once inhabited Pleistocene Lake Bonneville and which was thought to be extinct in Utah. The Snake Valley cutthroat is similar to *Salmo clarki utah* of the eastern Bonneville Basin; however, electrophoretic and morphomeristic analysis show unique genetic differences brought about by long-term isolation (8,000 years) from the remainder of the Bonneville Basin cutthroat. This cutthroat is a common ancestor to several other limited cutthroat populations within the basin in Nevada. In May 1977 the BLM withdrew from mineral entry about 27,000 acres within the Deep Creek Mountains for protection of this salmonid cutthroat and other unique resources on the range. Results of 1977 stream surveys on the Pilot Peak Mountain Range, Utah, indicate the presence of the threatened Lahontan cutthroat, *Salmo clarki henshawi*, in one isolated stream.

The ancient Pleistocene Lake Bonneville in the Great Basin once supported a cutthroat trout, native to the Snake Valley area of Utah-Nevada, which abounded in the area's several streams upon the lake's decline (Hickman 1977). Because of deteriorating habitat the cutthroat population rapidly diminished in the twentieth century to a point where it was believed to be extinct within its native range (Behnke 1976a) (Fig. 1).

In 1953 Ted Frantz, Nevada Fish and Game Department, discovered a cutthroat trout population in Pine Creek on Mt. Wheeler, Nevada (Frantz and King 1958). Samples were sent to Dr. Robert Miller, who indicated they represented pure cutthroat trout. But Dr. Miller was unable to assign them to any described subspecies (letter from Dr. Miller to F. Dodge, 26 May 1971). Though it was assumed this cutthroat was introduced from Trout Creek drainage of the Snake Valley area (Miller and Alcorn 1946), this seems unlikely when one considers that there were streams closer to Pine Creek which probably contained cutthroat trout (Lehman, Baker, Snake, and Hendrys creeks). Behnke (1976a) indicates the most logical origin of the Pine Creek cutthroat was from Lehman Creek (Mt. Wheeler tributary of the Snake Valley region) via the Osceola Ditch, constructed as a pioneer waterway.

During 1953 the Nevada Fish and Game Department introduced 44 fish from Pine Creek into Hampton Creek, Nevada. A second transplant of 54 cutthroat from Pine Creek was made into Goshute Creek, Nevada, in 1960. The Nevada Fish and Game Department, assuming these were Utah cutthroat, *Salmo clarki utah,* closed these streams to fishing and listed *S.c. utah* as an endangered species in Nevada. Mr. Frank Dodge, Nevada Fish and Game Department, in 1972 found a population of cutthroat trout in the headwaters of Hendrys Creek (Mt. Moriah tributary of the Snake Valley region) which resembled those found in Pine Creek. Following this, several unsuccessful attempts were made by the Nevada Fish and Game Department to locate additional pure populations of cutthroat trout in the Snake Valley area of Utah and Nevada.

In 1973 the BLM (Utah) began stream habitat surveys in the Deep Creek Moun-

---

[1] Department of Fishery & Wildlife Biology, Colorado State University, Fort Collins, Colorado.

[2] Fisheries Biologist, U.S. Bureau of Land Management, Utah State Office, University Club Building, 136 South Temple, Salt Lake City, Utah 84111.

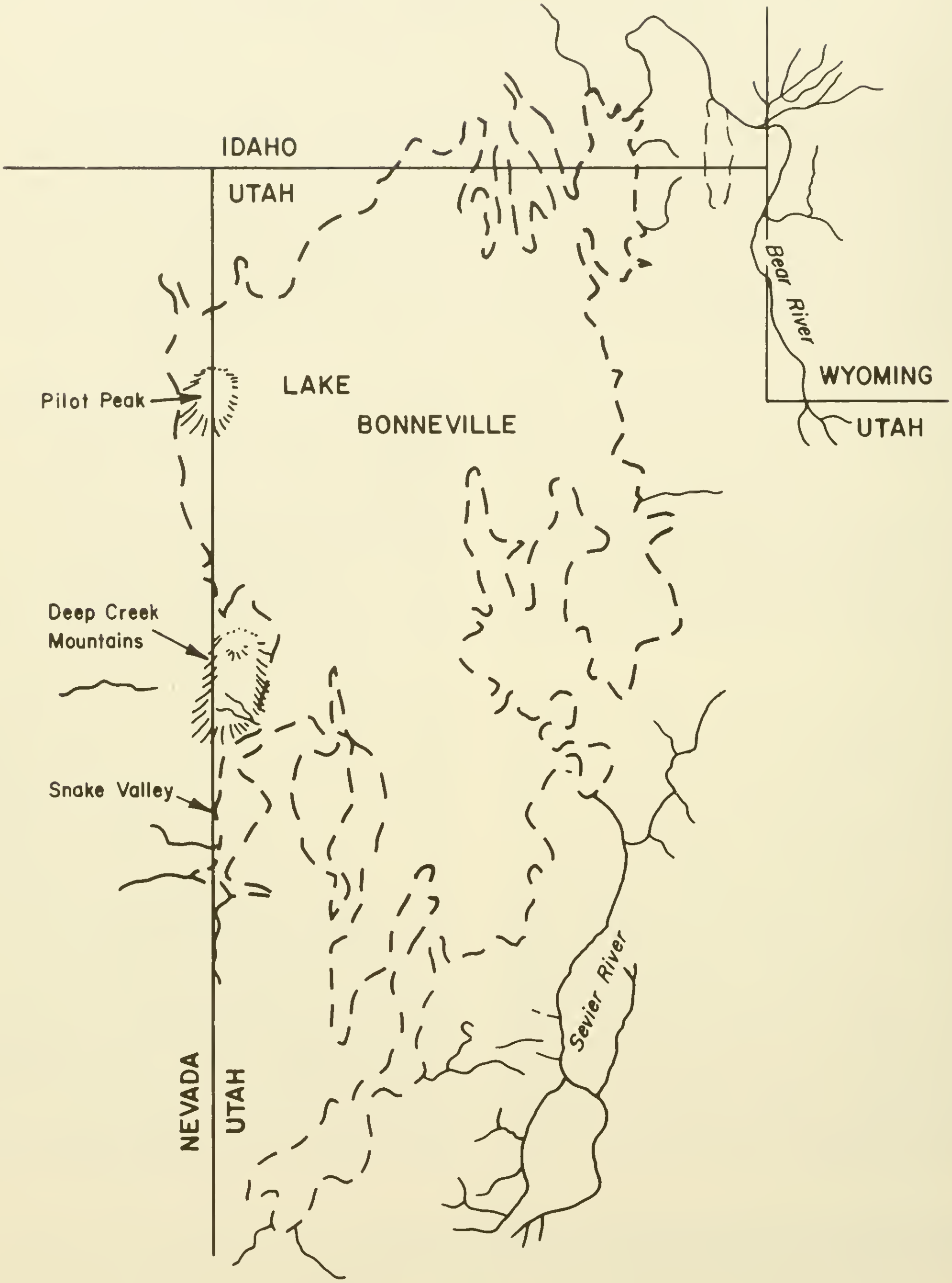

IDAHO
UTAH
Bear River
WYOMING
UTAH
Pilot Peak
LAKE
BONNEVILLE
Deep Creek Mountains
Snake Valley
Sevier River
NEVADA
UTAH

Fig 1. Area map location showing the western Bonneville Basin area.

tain Range in an attempt to define critical habitats and possible remnant populations of the cutthroat. In the spring of 1974, BLM biologists Don Duff and Josh Warburton discovered cutthroat in the extreme headwaters of Trout Creek, Utah, above a natural barrier falls. Subsequent sampling and analysis by the BLM, Utah Division of Wildlife Resources and Colorado State University (under contract funded by BLM) determined that Trout Creek specimens were pure strain fish of the Bonneville Basin. Inventories have continued to date, and the only stream found to contain a pure population was Trout Creek. Hybridized populations (with rainbow trout) were found in Birch Creek and Johnson Creek (Hickman 1977) (Fig. 2).

REASONS FOR DECLINE

When the Snake Valley arm of Lake Bonneville dried up, there were relatively few perennial streams in the area. In addition to this, since the mid 1800s, introductions of nonnative trouts, climatic conditions, irrigation practices, and habitat loss and degradation have been influential in reducing the number of cutthroat populations in the Snake Valley area. Replacement and hybridization from introductions of exotic rainbow trout (*Salmo gairdneri*) have posed the most significant impact to the survival of the Snake Valley cutthroat. Virtually every stream in the Snake Valley region capable of supporting trout has been stocked with rainbows. Brook trout are also capable of replacing the cutthroat through competition because of earlier spawning periods and its ability to become better adapted to life in small spring-fed headwater streams.

Exploitation, though not likely a limiting factor by itself, can reduce the number of catchables and may act to favor other exotics such as the brooks, browns, and hybrids. It has been documented that cutthroat trout are highly vulnerable to angling mortality (Behnke and Zarn 1976).

Livestock grazing imposes a subtle but serious threat to the survival of the cutthroat trout in the arid Snake Valley region. Grazing becomes significant when discussing sites for reintroductions, because much of the prime grasslands exist in headwater meadow areas. Livestock interests in the Bonneville Basin have been unconcerned about stream protection of rare trout populations. These problems have made the BLM very cautious in planning for additional habitat sites for future reintroductions of the Snake Valley cutthroat. Many studies have shown that livestock grazing destroys and degrades riparian vegetation and streambank soil stability, resulting in alterations of channel morphology, loss of cover, and a reduction in numbers and biomass of fish—particularly older and larger trout (Behnke 1977). Studies and management of livestock-impacted areas should be made in order to rehabilitate the grazed areas, either through improvement of the existing grazing system or livestock exclusion (Platts 1977). The BLM in Utah and Nevada has been involved in streamside fencing programs to protect the riparian habitat of streams containing sensitive or rare trout populations from continued livestock damage (Goshute Creek, Nevada, and Birch Creek, near Beaver, Utah).

Droughts and violent thunderstorms may have historically eliminated cutthroat populations from some high gradient streams, because natural recolonization could not be effective after desiccation of the pluvial lake in Snake Valley. This may account for the high number of barren streams found in the Snake Valley region prior to rainbow trout introductions.

Past surface disturbance impacts from mining have been slight and of short duration, the main damage resulting from equipment movement and road construction to and from the mine site. There exists little room for trails or roads in some of the narrow canyons; therefore, the streambed may be utilized for such purposes in some areas. Recent uranium mining activities in Utah's Deep Creek Mountains have caused concern over the future impacts of mining to the resources of this fragile desert island ecosystem environment.

The effects of all these environmental impacts on the cutthroat trout populations are

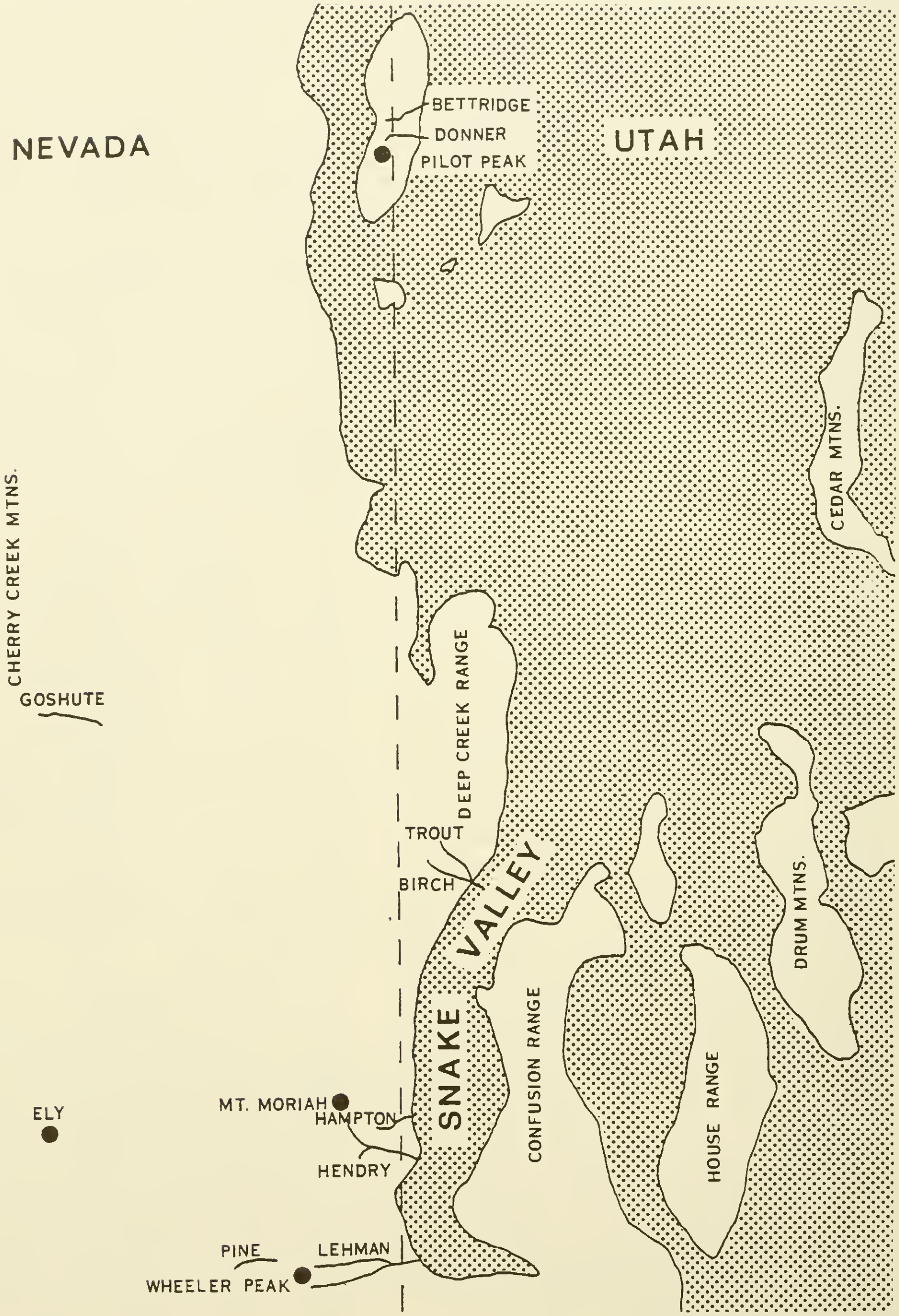

NEVADA
UTAH
BETTRIDGE
DONNER
PILOT PEAK
CHERRY CREEK MTNS.
GOSHUTE
CEDAR MTNS.
DEEP CREEK RANGE
TROUT
BIRCH
SNAKE VALLEY
CONFUSION RANGE
HOUSE RANGE
DRUM MTNS.
ELY
MT. MORIAH
HAMPTON
HENDRY
PINE
LEHMAN
WHEELER PEAK

Fig 2. Local area map showing extent of Lake Bonneville (shaded) in relation to perennial streams having cutthroat trout.

greatly magnified when considered collectively. Many of the streams in the Snake Valley region have been affected by all these major impacts at some time during the recent past history of the area.

UNIQUENESS OF SNAKE VALLEY CUTTHROAT TROUT

Ancient Lake Bonneville went through several periods of fluctuations in which water levels were closely associated with climatic conditions (Gilbert 1879). According to Broecker and Kaufman (1965), four low levels occurred between 8,000 and 22,000 years ago, including one period of complete desiccation followed by refilling that took place about 11,000 years ago. This final desiccation of Lake Bonneville resulted in 10 or 12 independent basins being formed, one of which was the Snake Valley basin (Gilbert 1890). The northern portions of Snake Valley show a lake level elevation of about 5,100 feet. This would have prevented water from flowing out of Snake Valley and into the Great Salt Lake basin. In addition to such physical isolation, the cutthroat were forced to seek refuge in the streams to overcome the increased saline conditions brought on by the desiccation (Hunt et al. 1953). Thus, many populations of cutthroat in the Bonneville Basin have been isolated from contact with each other for about 8,000 years.

Wydoski et al. (1976) studied the electrophoretic patterns of proteins in cutthroat located in the Bonneville Basin, as well as several other groups of cutthroat and rainbow trout. No protein was unique or distinctive for *S.c. utah* specimens, but an unusual variation for muscle lactate dehydrogenase (LDH) was found in cutthroat from Trout and Goshute creeks, indicating a common ancestor. This unusually complex variation seems to indicate the presence of a variant allele. A unique evolutionary event, or series of events, occurred in the Snake Valley cutthroat trout LDH, which would indicate long-term isolation from the rest of the Bonneville Basin cutthroat trout.

Comparison of samples of the least chub, *Iotichthys phlegethontis,* in the western Bonneville Basin adds credence to the assumption of incipient speciation in fishes isolated in Snake Valley. Samples from Donner Springs (Pilot Peak area) have the typical fin ray counts given by Sigler and Miller (1963). Those found in Snake Valley have one less ray in the dorsal (7), anal (6), and pelvic (7) fins.

Smith (1966) stated that the mountain suckers (*Catostomus platyrhynchus*), of Deep Creek in the Deep Creek Mountain area are different from the typical northern Bonneville form.

The Snake Valley cutthroat trout differs from other cutthroat trout of the Bonneville Basin by having more basibranchial teeth and gillrakers and fewer scales in the lateral line series. The spotting pattern is more uniformly distributed over the body and not so concentrated posteriorly as in other Bonneville Basin cutthroat. The head appears longer and deeper with the body being more compressed and the caudal peduncle deeper, all of which gives it a more chunky body appearance (Behnke 1976 a, b).

STATUS OF THE SNAKE VALLEY CUTTHROAT TROUT

Pure populations are found in Pine, Goshute, Hampton, and Hendrys creeks, Nevada, and in Trout Creek, Utah (Fig. 2). Hybridized populations are found in Muncy and Mill creeks, Nevada, and Birch and Johnson creeks, Utah (Behnke 1976a, Hickman 1977).

Goshute Creek probably has the highest number of Snake Valley cutthroat, having about 1,500 in four miles of stream (McLelland 1975). The Nevada BLM and Nevada Fish and Game Department (NFG) have been instrumental in protecting and enhancing the habitat in Goshute Creek. During the 1977 drought Goshute Creek lost about 38 percent of the cutthroat population per mile. Because of these conditions a concerned NFG took 71 cutthroat from Goshute Creek and transplanted them proportionately into Water Canyon Creek (four stream miles habitat) and Clear Creek (one stream mile habitat).

Pine Creek, a very small stream with little habitat, has about 100 cutthroats (excluding fry), as does Hampton Creek, which is also a small stream (McLelland 1975). Pine Creek suffered some mortality as a result of the 1977 drought. Mile Creek, another creek with transplanted cutthroat, lost its entire population as the creek dried up from the drought.

Hendrys Creek had about 200 cutthroat in the headwater area in 1973. In 1974 eradication of rainbow trout below the barrier was conducted on Hendrys Creek to aid the fish's survival. Hendrys, Goshute, and Pine creeks are now closed to angling use. Goshute and Hampton creeks have past histories of losing all their fish from flash floods, and this is the reason they were barren in 1953 and 1960. Because of its small size, Pine Creek is also vulnerable to flash flooding. Therefore, the potential exists that the cutthroat populations in these streams could be lost in the future. During the 1977 drought NFG estimates that 50 percent of the cutthroat populations in Hendrys and Hampton creeks were lost because of dry stream sections. In the interest of managing these unique fish, NFG has identified about 25 streams suitable for reintroductions. They plan to rehabilitate about two to four streams per year in this effort.

During 1977 one of the most significant events to take place in the basin for the protection of desert fishes and the environment occurred in the Deep Creek Mountains, when the BLM filed for an emergency withdrawal of a 27,000-acre area of critical environmental concern within the mountain range. Increased uranium mining activity threatened to destroy many of the unique resources of the mountain area. A significant factor in justifying this action was the presence of the rare Snake Valley cutthroat in only about 1¼ miles of critical habitat on Trout Creek, as well as the presence of the rare giant stonefly (*Pteronarcys princeps*). The area was withdrawn from mineral entry on 3 May 1977 by the Secretary of the Interior under section 204(e) of the Federal Land Policy and Management Act of 1976 (PL 94-579). This withdrawal stays in effect for a three-year period and allows time for study of all resources to ascertain their values.

In September 1977, the BLM (Utah) funded a contract to the Utah Division of Wildlife Resources to provide for an inventory of all fish and wildlife resources on the mountain range. The contract will last until April 1979 and will provide BLM with inventory data necessary to evaluate the future withdrawal status. It is hoped the contract will define possible other streams inhabited by the cutthroat on the mountain.

In late October 1977, the Utah Division of Wildlife Resources (DWR) eradicated the rainbow trout below the natural falls barrier on Trout Creek as a start to implement management plans designed to expand the cutthroat population. Future plans call for the transportation of cutthroat from Trout Creek into the headwaters of Red Cedar Creek, a remote stream on the mountain which was given first priority for transplant efforts. The DWR plans to rehabilitate about seven additional east slope streams to enhance cutthroat survival back into their historic range. A habitat management plan (HMP) being developed for the entire mountain ecosystem by the BLM, in cooperation with the Utah Division of Wildlife Resources, will specify management of all east slope streams for the cutthroat. The complete HMP is scheduled for completion in 1978-79 for all the mountain resources, of which the cutthroat is an integral part. At present the BLM has developed an HMP for Trout Creek, having begun implementation of this plan in 1977 via Sikes Act (P.L. 93-452) authorities. Using Youth Conservation Corps (YCC) workers, some 75 long-type stream improvement structures were constructed in July in Trout Creek to aid the bank stabilization and pool quality enhancement for the cutthroat. Stream improvement work is scheduled again in 1978 by BLM using the YCC.

Although there are differences in the taxonomic characters between S. *c. utah* and the cutthroat found in Snake Valley, there also exists much overlap. Basibranchial teeth counts, which seem to be a distinctive characteristic separating the two forms, were found to be similar in number in one S. *c. utah* sample from Willow Creek, Jordan River drainage, Utah (Hickman 1977). With the analysis of more samples from the Bonneville Basin, the degree of overlap between these cutthroat becomes more obvious. This overlap is further substantiated through the use of a computer-aided discriminant function analysis, which evaluates the similarities and differences between samples (Hickman 1977). Sixteen (16) morphomeristic character measurements (Table 1) from samples of various described and undescribed subspecies of cutthroat trout, and one sample of rainbow trout, were compared (Fig. 2). The closer the group centroid (represented by dot in Fig. 3), the more similar the samples. The cutthroat trout in Snake Valley and *S. c. utah* are closely situated, indicating a high degree of similarity. Of interest is the similarity depicted in the discriminate function plot between *S. c. pleuriticus* (Colorado River Cutthroat) and *S. c. stomias* (Greenback cutthroat). This supports the taxonomic evaluations of Behnke and Zarn (1976) that *S. c. pleuriticus* gave rise to *S. c. stomias* via an ancient headwater transfer, and that there exists little taxonomic difference between the two subspecies.

To avoid taxonomic confusion, which has led to subspecies classification delays, the cutthroat trout in Snake Valley should be considered a unique form of *S. c. utah. Salmo c. utah* is not abundant in any portion of its native range, and at one point it was thought to be extinct as a pure form (Miller 1950, Cope 1955, Platts 1957, Sigler and Miller 1963). The 1973 version of the U.S. Department of Interior's "Red Book" of endangered and threatened species listed *S. c. utah* as "status undetermined"; the International Union for the Conservation of Nature (1969) listed it as rare; Holden et al. (1974) considered it endangered; the Wyoming Game and Fish Department lists it as rare; the Nevada Fish and Game Department considers it endangered; and Behnke (1973, 1976b) considers it to be rare with a highly restricted distribution.

Table 1. Morphomeristic characters used in the discriminant function analysis, 1977.

Head length	Gillrakers lower
Upper jaw length	Gillrakers total
Snout tip to dorsal fin origin	Branchiostegal rays right
	Branchiostegal rays left
Dorsal fin length	Scales above latera line
Caudal peduncle depth	Pelvic fin rays
Caudal peduncle length	Pyloric caeca
Gillrakers upper	Basibranchial teet

Cutthroat Discovery in the Pilot Peak Range

In an effort to locate additional populations of Bonneville Basin cutthroat trout, a survey of the Pilot Peak Range (North of Wendover on the Utah-Nevada border) was conducted in 1977 by the BLM and Colorado State University (under a contract funded by BLM).

As a result of these surveys, only two streams were found containing sufficient annual flows to support trout populations. One stream, to the north of Pilot Peak, Bettridge Creek, has an abundant population of rainbow trout which were first stocked by the Utah Division of Wildlife Resources in the 1940s or early 1950s. The other stream, located in the adjacent canyon to the south of Bettridge Creek, is unnamed (for the present we have called it Donner Creek because it historically drained into Donner Springs). The city of Wendover, Utah, obtains a portion of its water supply from this creek.

Mr. Kent Sumners, Utah Division of Wildlife Resources, discovered the cutthroat in Donner Creek in April 1977 while sampling the stream at the request of the BLM. Subsequent specimen collection by the authors and their later analysis at Colorado State University confirmed this classification. Taxonomic analysis of the 17 trout sampled from Donner Creek proved most interesting. They are pure strain cutthroat trout (no sign of hybridization) and have a higher gillraker count than any other cutthroat population (24–29, avg. 26.1).

The origin of this cutthroat is uncertain; however, Howard Gibson, retired water master for the city of Wendover, indicated that the cutthroat were in Donner Creek when he commenced work on the stream in 1952 (pers. comm. with H. Gibson, Wendover, Utah). None of the other local residents contacted could provide any information pertaining to the cutthroat, and most were unaware of its existence in Donner Creek. The Nevada Fish and Game Department has no record of cutthroat stockings in the Pilot Peak Range (letter to Don Duff, BLM, SLC from Pat Coffin, Nevada Fish and Game Dept., Elko, October 1977). The only cutthroat exhibiting such high gillraker numbers is the Lahontan cutthroat trout (*S. c. henshawi*) (Behnke and Zarn 1976). The most probable origin of the Donner Creek cutthroat is Pyramid Lake, because, from the late 1890s to 1930, cutthroat trout from Pyramid Lake were stocked extensively in Nevada. In 1910 Elko County received a large shipment of eggs, but no records exist on where these fish were stocked. Little stocking of Lahontan cutthroat occurred from 1931–1942, but in 1950 Lahontan trout from Summit Lake, Nevada, were used for stocking. After 1930 *S. c. henshawi* was considered rare, and it seems unlikely that a creek in the Pilot Range would be stocked with this cutthroat subspecies.

The discriminant function analysis (Table 1, Fig. 3) indicates that the cutthroat from Donner Creek are the most similar to *S. c. henshawi.*

SUMMARY

The Snake Valley cutthroat, a form of *S. c. utah,* is a unique desert fish resource located in the western Bonneville Basin which is worthy of protection and management for the scientific community as well as the American public. *S. c. utah* has promising possibilities for enhancing the basin states' fishery programs for wild trout manage-

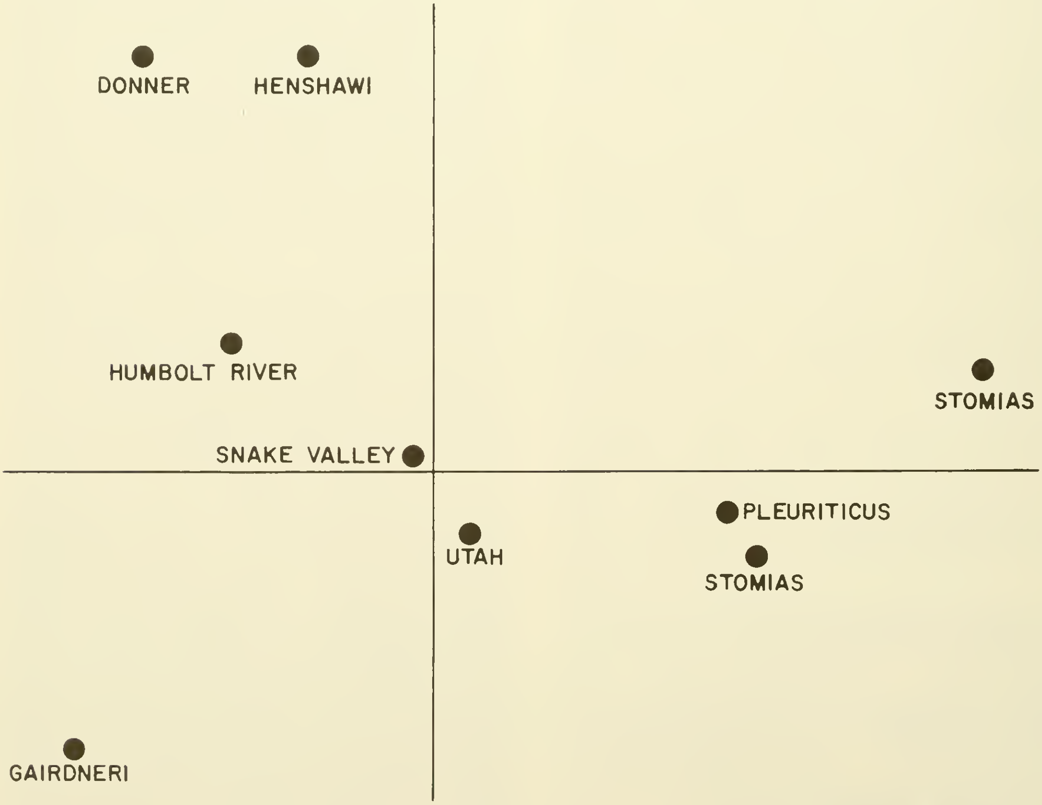


Fig. 3. Discriminant function plot analysis chart showing relationship to cutthroat subspecies based on morphomeristic characters.

ment. The 1975 listing of endangered and threatened fishes of the western U.S. developed by the Desert Fishes Council did not consider this subspecies in its listing of sensitive western fishes. It is hoped that recognition of this subspecies for management concern will serve as an aid to organizations and agencies responsible for the management of habitat and this subspecies in the future. The ultimate management design for this subspecies and all others so recognized is to provide management to a degree whereby survival and protection of the species and its habitat are assured, so official status classification by the U.S. Fish and Wildlife Service is not necessary. However, should environmental conditions continue to deteriorate and this subspecies eventually become listed by the U.S. Fish and Wildlife Service, then a classification of "threatened" would provide the necessary protective status while still allowing for state-federal recovery programs to function.

The interest in desert fishes management has intensified by agencies and the scientific community by the discovery in 1977 of *S. c. henshawi* in Donner Creek of the Pilot Peak Mountain Range. The major significance of this find of *S. c. henshawi* is that it very likely represents the original Pyramid Lake genotype—the largest trout native to western North America and long believed to be extinct (Trojnar and Behnke 1975, Behnke and Zarn 1976). This find is worthy of intense management effort by the Utah Division of Wildlife Resources (DWR) and the BLM because the existence of this pure strain fish is extremely limited, as indicated by its official threatened status by the U.S. Fish and Wildlife Service. Colorado State University is continuing contract studies on this mountain range for the BLM. The BLM in Utah plans to implement the Pilot Peak Mountains HMP in 1978 under Sikes Act authorities in cooperation with the DWR. Stream habitat improvements are being planned for Bettridge Creek, which at present has a natural reproducing population of rainbow trout. This creek could serve in the future as a possible transplant site for the Lahontan cutthroat in Donner Creek. Both creeks have good stream habitat, being in a relatively undisturbed state from man and livestock activities and located in a remote area adjacent to the arid wastes of the Great Salt Lake desert salt flats.

Literature Cited

Behnke, R. J. 1973. Status report: Utah or Bonneville cutthroat trout, *Salmo clarki utah.* Prepared for Region 2 U.S. Fish and Wildlife Service, Albuquerque, N.M. 4 pp.

______. 1976a. A summary of information on a unique form of cutthroat trout native to the Snake Valley section of the Bonneville Basin, Utah and Nevada. Prepared for BLM, Salt Lake City, Utah. 18 pp.

______. 1976b. Summary of information on the status of the Utah or Bonneville Basin cutthroat trout, *Salmo clarki utah.* Prepared for Wasatch National For., Salt Lake City, Utah. 14 pp.

______. 1977. Livestock grazing impact on stream fisheries: problems and suggested solutions. Paper presented at Livestock and Wildlife-Fisheries Workshop, Sparks, Nevada, May 1977. 10 pp.

Behnke, R. J., and M. Zarn. 1976. Biology and management of threatened and endangered western trouts. USDA Forest Service general technical Rept. Rm-28. Rocky Mountain Forest and Range Exp. St., Fort Collins, Colorado. 45 pp.

Broecker, W. S., and A. Kaufman. 1965. Radio carbon chronology of Lake Lahontan and Lake Bonneville II, Great Basin. Bull. Geol. Soc. Amer.:76:537–566.

Cope, O. B. 1955. The future of the cutthroat trout in Utah. Proc. Utah Acad. Sci. Arts and Lett.:32:89–93.

Duff, D. A. 1974. Reconnaissance survey for Utah cutthroat aquatic habitat in the Deep Creek Mountains. BLM Utah State Office, unpublished report. 6 pp.

Frantz, T. C., and D. J. King. 1958. Completion report, Nevada Fish and Game Commission, Stream and Lake Survey. 188 pp.

Gilbert, G. K. 1879. *In:* J. W. Powell (ed.), Lands of the arid region, pp. 50–65.

______. 1890. Lake Bonneville. Monogr. U.S. Geol. Surv., 438 pp.

Hickman, T. J. 1977. Studies on relict populations of Snake Valley cutthroat trout in western Utah 1976. U.S. BLM, Utah State Office, 41 pp.

Holden, P. B., W. White, G. Sommerville, D. Duff, R. Gervais, and S. Gloss. 1974. Threatened fishes of Utah. Proc. Utah Acad. Sci. Arts and Lett. 51(2):46–55.

Hunt, C. B., H. Varnes, and H. Thomas. 1953. Lake Bonneville geology of northern Utah Valley, Utah. U.S. Geol. Surv. Prof. Pap. 15 pp.

McLelland, W. L. 1975. Cutthroat trout investigation, Mt. Wheeler cutthroat trout, White Pine County, Region II. Nevada Fish and Game Department. Prog. No. F-20-11 Job No. 207. 24 pp.

Miller, R. R. 1950. Notes on the cutthroat and rainbow trouts with the description of a new species from the Gila River, New Mexico. Occasional Pap. Mus. Zool. Univ. Mich. (529):42 pp.

Miller, R. R., and J. R. Alcorn. 1946. The introduced fishes of Nevada, with a history of their introduction. Trans. Am. Fish. Soc. 73, 1943:173–193.

Platts, W. S. 1957. The cutthroat trout. Utah Fish and Game Magazine, 13(10):4,10.

______. 1977. Livestock interactions with fish and their environment. Paper presented to Calif.-Nevada AFS. 12 pp.

Sigler, W. F., and R. R. Miller. 1963. Fishes of Utah. Utah Dept. Fish and Game. 203 pp.

Smith, G. R. 1966. Distribution and evolution of the North American catostomid fishes of the subgenus *Pantosteus*, genus *Catostomus*. Miscl. Publ. Mus. Zool. Univ. Mich. (129):132 pp.

Trojnar, J. R., and R. J. Behnke. 1974. Management implications of ecological segregation between two introduced populations of cutthroat trout in a small Colorado Lake, Trans. Amer. Fish. Soc. 103:423–430.

Wydoski, R. S., G. Klar, T. Farley, J. Braman, Y. Kao, and C. Stalnaker. 1976. Genetic biochemical and physiological studies of trout enzymes. NMFS Final Rept. Prog. No. I-87R. 163 pp.

REPRODUCTIVE BIOLOGY OF THE TUI CHUB, *GILA BICOLOR*, IN PYRAMID LAKE, NEVADA

Paul A. Kucera[1]

Abstract.— Sex ratios for tui chubs (*Gila bicolor*), obtained from a sample of 3,384 fish, deviated significantly from the expected 1:1 ratio (chi-square, $P<0.05$). Spawning occurred from June to August, with estimated fecundities ranging from 6,110 to 68,933 ova. Females spawned after attaining a maximum (average) gonadal somatic index (GSI—percent gonad weight/total body weight) of 9.1 percent and between surface water temperatures of 15.5 to 22.2 C. Males reached sexual maturity at age two, with most females maturing at age three. Consistent increases in fecundity were apparent with increasing length, weight, and age. Linear regressions between fork length and fecundity and weight and fecundity were highly significant ($P<0.05$).

The tui chub (*Gila bicolor*) is a cyprinid found in the drainage systems on both sides of the Sierra Nevada, from the San Joaquin and Lahontan systems north to the lakes of southern Oregon and the Columbia River (LaRivers 1962). In Pyramid Lake *G. bicolor* comprises nearly 89 percent of the net catch and represents the main forage base for the Lahontan cutthroat trout (*Salmo clarki henshawi*). Tui chubs also represent a principal component in the bioenergetics of the Pyramid Lake ecosystem.

The present study is a part of the total ecological research and fish life history studies being conducted on Pyramid Lake. Those aspects of the reproductive biology that were studied included: sex ratios, total and by month; changes in fish catch rates and sex ratios; development of the ova and ovaries in relation to the spawning season; age and size at sexual maturity; and number of ova in relation to fish length and weight.

Methods

Tui chubs were collected monthly from November 1975 through June 1977 in Pyramid Lake, Nevada. Two gear types were utilized in the collection of chubs: variable-mesh bottom-set gill nets and fyke nets. Females selected for fecundity studies were collected during June and July of 1976 and 1977. These months were selected to ensure collection of ripe females.

Ovaries were removed from 23 tui chubs for fecundity determination. Each pair of ovaries was weighed to ± 1 mg, and 10 ovum diameters per ovary were measured to the nearest 0.1 mm with an ocular micrometer. The fork length of each fish was measured to the nearest millimeter, and each fish was weighed to the nearest gram. All fecundity determinations were made with fresh ovaries.

Fecundity was estimated by the gravimetric method (Jester 1973; June 1971). Three replicate subsamples of approximately 0.5 g were taken from each ovary, weighed to the nearest 1 mg, and preserved for later counting. Fecundity was then calculated by direct proportion per ovary.

Sex ratios were obtained through internal examination of 3,384 fish. Age groups were assigned by the scale method and length frequency histograms. Linear and $\log_{10}$ regressions between fecundity and fork length and fecundity and weight were used to examine the relationships between these variables.

Discussion

Sex ratios for tui chubs were obtained from a sample of 3,384 fish sampled from

---

[1] W. F. Sigler & Associates Inc., 1005 Terminal Way, Suite 155, Reno, Nevada 89502.

TABLE 1. Monthly sex ratios of adult tui chubs sampled from November 1975 through February 1977 in Pyramid Lake, Nevada.

	Months															
	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F
Males	60	74	52	14	76	96	126	462	93	95	79	87	56	31	92	46
Females	91	104	84	51	171	179	134	289	106	75	76	96	100	80	155	54
Ratio M:F	1:1.52	1:1.41	1:1.62	1:3.64	1:2.25	1:1.86	1:1.06	1.6:1	1:1.14	1.27:1	1.04:1	1:1.1	1:1.78	1:2.58	1:1.68	1:1.17

November 1975 through February 1977. The 1:1.20 ratio, 1,539 males to 1,845 females, represents a significant deviation from the expected 1:1 ratio (chi-square, $P<0.05$). Sex ratios by month (Table 1) present interesting fluctuations. Substantial deviations in sex ratios for duplicated months (December and February) are readily apparent and heavily favor the females. This is probably the result of sampling bias. The important trend takes place from April through August, which coincides with the spawning season. In April, the ratio of males to females is almost 1:2. This changes dramatically in May to 1:1.06, in June to 1.6:1, to 1:1.14 in July, and 1.27:1 in August. Deviations in sex ratios in May and June could be attributed to the movement of males to spawning sites. Of 262 tui chubs sexed from one inshore bottom gill net in early June 1976, 86 percent were males. Data collected from Walker Lake, Nevada (Cooper, personal communication), in mid-June parallel this result (85 percent of the tui chubs sampled in 5–7 m of water were males).

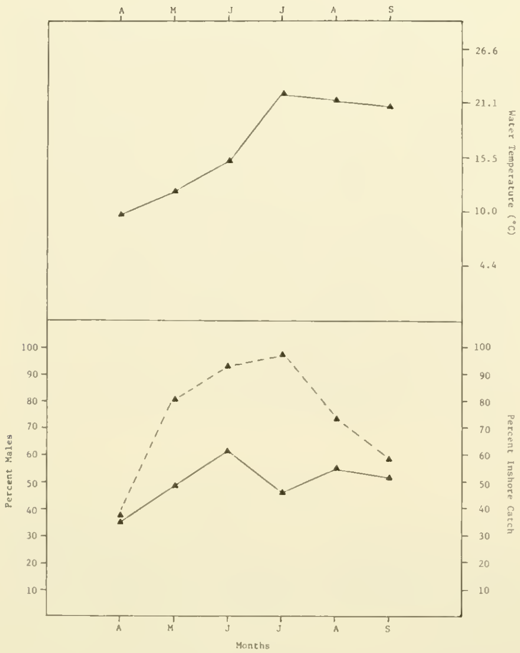


Fig. 1. Monthly changes in sex ratios (solid line) and inshore catch rates (dash line) of tui chubs in Pyramid Lake in 1976. Water temperatures are monthly inshore surface averages.

Increases in the percentage of males sampled from April through June are accompanied by an increased bottom inshore catch of tui chubs (Fig. 1). Although monthly sex ratios were shown to be variable (Table 1), they usually favored the females. From May to June, the percent of males increased from 49 to 62 percent, indicating a prespawning movement of males inshore. Catch rates also increased dramatically in May, and steadily rose in June. An influx of females in July, corresponding to peak spawning, decreased the percentage of males to 46 percent. Increased activity, and thus increased catches, for both sexes, also parallel major periods of zooplankton standing crops, macroinvertebrate abundances, increasing water temperatures, feeding habits, and growth rates. The overall catch rate inshore in August decreased by 71 percent from the bottom inshore average numbers of June and July. This corresponds with the completion of the spawning season and must result from differential behavior and distribution of mature fish related to spawning.

Constant increases in the average female gonadal somatic index (GSI—percent gonad weight/total body weight) were noted from February through May, with a major increase of 3.8 percent in June (Fig. 2). This period of major germinal growth (May to June) took place after the major increase in somatic growth (fork length) in fall and winter. Consequently, tui chubs foraged very actively to support both germinal and somatic increases. Females attained a maximum average GSI in June of 9.2 percent as inshore water temperatures approached 15.5 C. Zooplankton standing crops and macroinvertebrate abundances were both high during this period, thus providing ample food sources. Spawning occurred from June to August, with peak spawning in July when the GSI dropped from 7.3 percent to 1.5 percent in August. Inshore water temperatures in June were 15.5 C and in July were 22.2 C. In Eagle Lake, California, tui chubs spawned when water temperatures reached about 15.5 C (Kimsey 1954). Spawning activity of Mojave chubs, *Gila mohavensis*, in Soda Lake, California, peaked in mid-March at water temperatures of 18 C (Vicker 1973).

LaRivers (1962) states that tui chubs congregate along the shoreline during the spawning season. Bottom gill net catches reveal that almost 97 percent of the tui chubs were inshore in July. This corresponds with the time of peak spawning. Although no spawning activity or spawn was observed during this study, chubs have been seen spawning in shallow water in Pyramid Lake (Galat, pers. comm.). Initiation of sampling during the summer of 1977 to determine vertical distribution patterns suggested the possibility of two separate chub populations: a fine-rakered limnetic population and a coarse-rakered population. The tax-

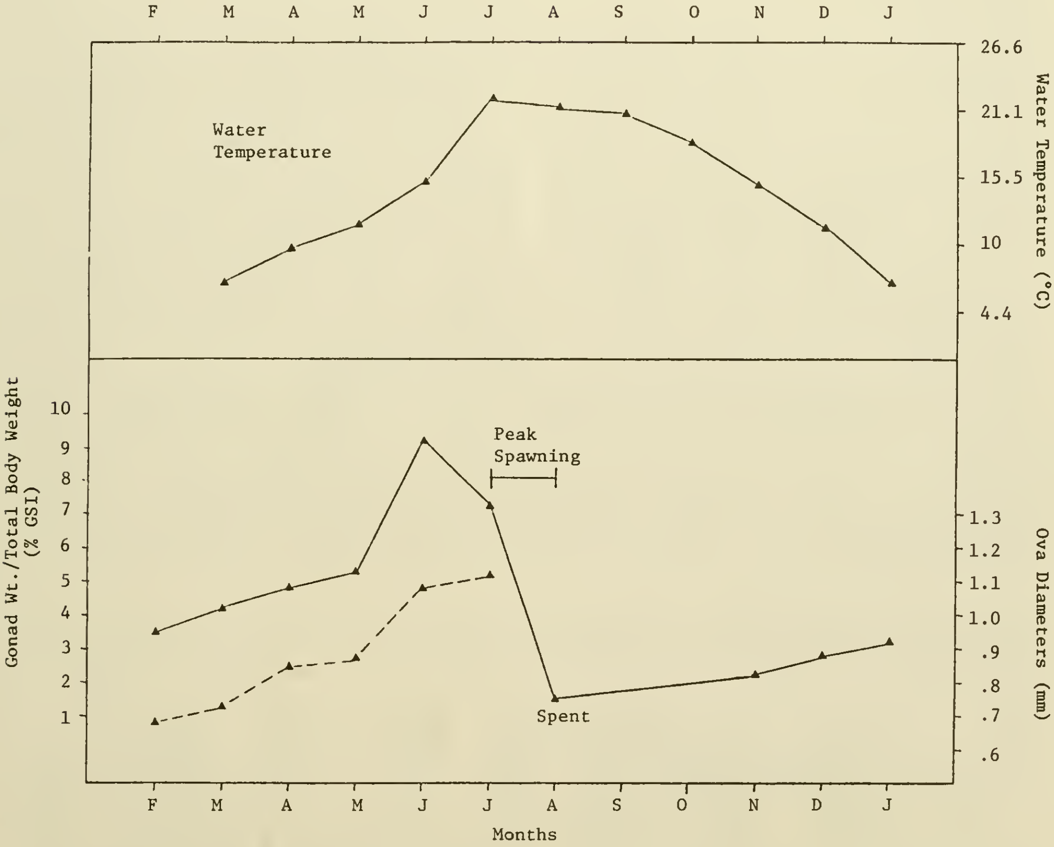


Fig 2. Comparison of monthly tui chub gonadal somatic index values (solid line) with ova diameters (dash line). Water temperatures are monthly inshore surface averages.

onomic controversy concerning the tui chub is well documented (Hubbs and Miller 1943, Hubbs et al. 1974, Kimsey 1954, LaRivers and Trelease 1952, LaRivers 1962). It is believed that the spawning discussion includes the bottom-dwelling chubs, but the paucity of data on pelagic chubs precludes any conclusion that they also spawn inshore. Varley and Livesay (1976) observed movement of prespawning and spawning populations of Utah chub, *Gila atraria*, in Flaming Gorge Reservoir, Utah-Wyoming. In the summer these chubs move onshore into littoral areas from mid to late afternoon, apparently to spawn, and then move lakeward into pelagic areas by early morning hours. Diel distribution patterns of Utah chubs in Fish Lake, Utah (Gaufin 1964), also indicate concentrations of chubs in littoral areas during the night.

In Pyramid Lake, female tui chubs are sexually mature at two years of age, and all are mature by age three; the majority of males also mature at two and all by three. After attaining sexual maturity, chubs ripen and spawn every year. The oldest mature female sampled was of age group VII, and the oldest mature male was of age group IV. Upon attaining maturity, Utah chub males showed a higher rate of mortality as age group V, and older females outnumbered males almost 10 to 1 (Varley and Livesay 1976).

Age group III chubs comprised the majority of females sampled for fecundity studies (Table 2). Three-year-old females averaged 232 mm in fork length and 15,135 ova per female. Age group IV females averaged 277 mm in fork length and 31,622 ova per female. One age group V female was 307 mm in fork length and contained an estimated 50,032 ova. One age group VII female was 378 mm long and contained an estimated 68,933 ova. Estimated egg production per female ranged from 6,110–68,933 eggs and averaged 23,292 ova. Olson (1959) found the average number of eggs for Utah chubs from Scofield Reservoir, Utah, to be 25,282 ova per female. In Hebgen Lake, Montana, Graham(1955) found Utah chub fecundities to average 40,750 eggs per female, although his sample size of $n = 7$ was small. Estimated fecundities for six Mojave chubs averaged 12,687 ova per female (Vicker 1973). Tui chubs exhibited consistent increases in fecundity, with increases in length, weight, and age (r values; $P < 0.05$). Ova diameters, from green ovaries, ranged from 1.1–1.7 mm and averaged 1.3 mm for all year classes. Kimsey (1954) described newly extruded tui chub eggs as being 1.5–1.9 mm in diameter, and Harry (1951) stated that freshly stripped tui chub eggs were 1.8–2.0 mm in diameter.

The linear relationship between fork length and fecundity (Fig. 3) was highly significant ($F = 94.8$; $P < 0.05$). A significant ($P < 0.05$) correlation coefficient exists between fork length and fecundity, because 82 percent of the variation in fecundity was accounted for by variation in length. The positive linear relationship between weight and fecundity was also highly significant ($F = 211.2$; $P < 0.05$), demonstrating an increase in fecundity with increasing weight (Fig. 4). A significant ($P < 0.05$) correlation coefficient exists, and 91 percent of the variation in fecundity was explained by variation in weight. Both fork length and fecundity and weight and fecundity had

Table 2. Average lengths, weights, ovum diameters, and fecundities, per age group, for 23 tui chub from Pyramid Lake, Nevada, 1976 and 1977.

Number of Tui Chub	Age Group	Range in Fork Length (mm)	Average Fork Length (mm)	Range in Weight (grams)	Average Weight (grams)	Range in Egg Diameter (mm)	Average Diameter (mm)	Range in Number of eggs	Average Number
15	III	210–252	232	96–238	154	1.1–1.5	1.3	6,110–31,432	15,135
6	IV	263–323	277	196–410	317	1.2–1.4	1.3	19,307–36,993	31,622
1	V	–	307	–	444	–	1.3	–	50,032
–	VI	–	–	–	–	–	–	–	–
1	VII	–	378	–	661	–	1.35	–	68,933

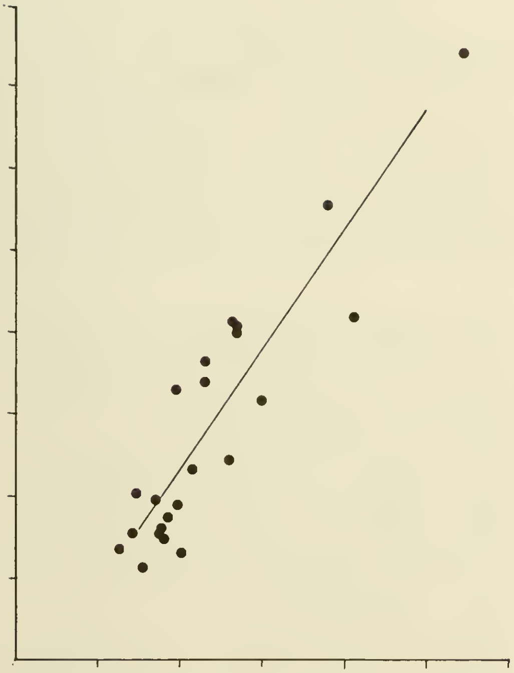


Fig. 3. The relationship between fork length and fecundity for 23 tui chubs from Pyramid Lake, Nevada, 1976 and 1977.

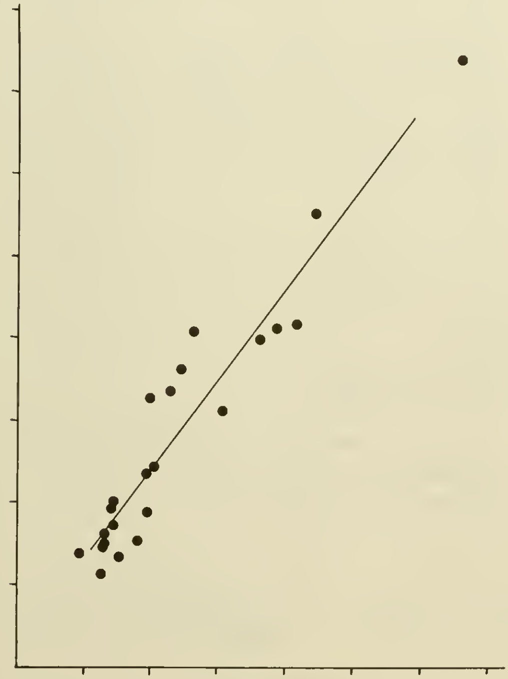


Fig. 4. The relationship between weight and fecundity for 23 tui chubs from Pyramid Lake, Nevada, 1976 and 1977.

significant $\log_{10}$ fits but were best described by a linear fit.

ACKNOWLEDGMENTS

I wish to acknowledge the entire crew of W.F. Sigler & Associates Inc., especially Steven Vigg and Denise Robertson, for assistance and support in this project.

LITERATURE CITED

GAUFIN, R. F. 1964. Ecology of the Utah chub in Fish Lake. Master's thesis, Univ. of Utah. 111 pp.

GRAHAM, R. J. 1961. Biology of the Utah chub in Hebgen Lake, Montana. Trans. Amer. Fisheries Soc. 90(3):269–276.

HARRY, R. R. 1951. The embryonic and early larval stages of the tui chub, *Siphateles bicolor* (Girard), from Eagle Lake, California. California Fish and Game 37(2):129–132.

HUBBS, C. L., AND R. R. MILLER. 1943. Mass hybridization between two genera of cyprinid fishes in the Mohave Desert, California, Michigan Acad. Sci., Arts and Letters 28:343–378.

HUBBS, C. L., R. R. MILLER, AND L. C. HUBBS. 1974. Hydrographic history and relict fishes of north-central Great Basin. *In*: Memoirs of the California Acad. of Sci. 259 pp.

JESTER, D. B. 1973. Life history, ecology, and management of the smallmouth buffalo, *Ictiobus bubalus* (Rafinesque), with reference to Elephant Butte Lake. Agric. Exp. Stn. Res. Rep. 261, New Mexico State University, Las Cruces. 111 pp.

JUNE, F. C. 1971. The reproductive biology of northern pike, *Esox lucius*, in Lake Oahe, an upper Missouri River storage reservoir, *In*: G. E. Hall (ed.), Reservoir fisheries and limnology. pp. 53–71. Spec. Publ. 8, Am. Fish. Soc.

KIMSEY, J. B. 1954. The life history of the tui chub, *Siphateles bicolor* (Girard), from Eagle Lake, California. California Fish and Game 40(4):395–410.

LARIVERS, I. 1962. Fishes and fisheries of Nevada. Nevada State Fish and Game Comm. 782 pp.

LARIVERS, I., AND T. TRELEASE. 1952. An annotated checklist of the fishes of Nevada. California Fish and Game 38(1):113–123.

OLSON, H. F. 1959. The biology of the Utah chub, *Gila atraria* (Girard), of Scofield Reservoir, Utah. Master's thesis, Utah State University. 34 pp.

VARLEY, J. D., AND J. C. LIVESAY. 1976. Utah ecology and life history of the Utah chub, *Gila atraria*, in Flaming Gorge Reservoir, Utah-Wyoming. Utah Division of Wildlife Resources Pub. No. 76-16. 29 pp.

VICKER, C. E. 1973. Aspects of the life history of the Mojave chub, *Gila bicolor mohavensis* (Snyder) from Soda Lake, Calif. Master's thesis, California State University, Fullerton. 27 pp.

DISTRIBUTIONAL RECORDS FOR THE COLORADO FLORA

D. Wilken[1], W. Harmon[2], C. Feddema[3]
and H. Harrington[1]

Abstract.— Nine new records of vascular plants indigenous to western North America, six new records of adventive taxa, and six significant range extensions are reported for the flora of Colorado.

The following collections document new records and range extensions for vascular plants as treated by Harrington (1954), Weber (1976), and Weber and Johnston (1976). Herbarium citations follow the recent treatment by Holmgren and Keuken (Index Herbariorum, Ed. 6, 1974).

Indigenous New Records

X *Agrositanion saxicola* (Scribner & Smith) Bowden

Mesa Co.: 2 miles south of Monument Hill, 9,700 ft, 28 August 1947, W. A. Weber 3660 (CS). This specimen possesses the narrow, bifid to trifid glumes, long divergent awns, and tardily disarticulating rachis characteristic of *Sitanion* X *Agropyron* hybrids discussed in Cronquist et al. (1977).

***Astragalus musiniensis* Jones**

Garfield Co.: Badger Wash Experimental Area, 10 miles northwest of Mack, 5,000 ft, 7 June 1973, Reid & Ranck s.n. (USFS).

***Conimitella williamsii* (D.C. Eaton) Rydberg**

Summit Co.: along Pass Creek, 2 miles east of State Highway 9, along Ute Pass Road, 8,600 ft, 26 June 1973, D. Walsworth s.n. (CS, USFS); 27 June 1975, W. A. Weber and P. Nelson 15119 (COLO, CS). This site represents a southward range extension of ca. 200 miles from the nearest previously known localities in northern Wyoming.

***Drymaria depressa* Greene**

Boulder Co.: 2.75 miles west of Copeland Lake, 9,700 ft, 16 August 1976, F. Hermann 27405 (CS).

***Erigeron ochroleucus* Nuttall**

Rio Blanco Co.: 6.6 miles north of Rio Blanco, 7,200 ft, 4 June 1977, Wilken and Schwab 13058 (CS). This collection documents predictions of its occurrence in Colorado by Harrington (1954) and Weber and Johnston (1976).

***Gilia micromeria* A. Gray**

Mesa Co.: Monument Valley Overlook, Colorado National Monument, 1,700 m, 11 May 1974, Wilken and Kelley 11988 (CS); Moffat Co.: near mouth of Hell Canyon-Yampa Canyon, 5,200 ft, 14 May 1948, Harrington 3906 (CS).

***Heliotropium convolvulaceum* (Nuttall) A. Gray var. *californicum* (Greene) Johnston**

Mesa Co.: Rabbit Valley Road, 4 miles south of Highway 50, 1,450 m, 6 July 1976, Wilken, Donahue and Tabar 12684 (CS). This population was represented by only several individuals and should be considered rare in Colorado. The typical variety occurs in local abundance in southeastern Colorado.

Parthenium alpinum* (Nuttall) Torrey & Gray var. *alpinum

Weld Co.: 3.5 miles north-northwest of junction of County Roads 45 and 122, 5,800 ft, 4 June 1977, Harmon 8919 (CS, GREE), Harmon 8810 (CS, GREE).

---

[1] Department of Botany and Plant Pathology, Colorado State University, Fort Collins, Colorado 80523.

[2] Department of Biological Sciences, University of Northern Colorado, Greeley, Colorado 80639.

[3] U.S. Forest Service Herbarium, Fort Collins, Colorado 80521.

Prunus angustifolia **Marshall**

Baca Co.: 33 miles southeast of Springfield, 4,200 ft, 26 July 1956, Harrington 8319 (CS).

Typha domingensis **Persoon**

Prowers Co.: 5 miles east of Lamar, 6 October 1957, Hotchkiss 7577 (CS); 1 mile south of Bristol, 3,400 ft, 27 July 1959, Harrington 9102 (CS).

Adventive New Records

Eragrostis curvula **(Schrader) Nees**

Lincoln Co.: 3 miles south of Hugo, 5,000 ft, 2 October 1957, Hamill s.n. (CS).

Fumaria officinalis **L.**

Weld Co.: 2 miles west of Windsor, 4,780 ft, 31 May 1957, Klein s.n. (CS). Recent observations by the senior author indicate that the population is well established and spreading along an irrigation ditch.

Anoda cristata **(L.) Schlechtendahl**

Otero Co.: Experiment Station near Rocky Ford, 12 October 1966, Swink s.n. (CS).

Montia perfoliata **(Donn) Howell**

Douglas Co.: T. 7 S., R. 69 W., S. 4, 6,000 ft, 14 May 1960, Brunquist s.n. (CS). Efforts to relocate this population have been unsuccessful. Although indigenous to the Pacific Northwest and with nearest known natural populations in northeastern Wyoming, this record is considered to be adventive.

Prunus armeniaca **L.**

Garfield Co.: Glenwood Canyon, 4.4 miles east of No Name, 6,200 ft, 26 May 1977, Wilken 12935 (CS). First reported as established in Mesa Verde National Park (Welsh and Erdman 1964), this species is well established and reproducing in Glenwood Canyon.

Puccinellia lemmonii **(Vasey) Scribner**

Boulder Co.: north of Valmont Rd., between the railroad line and Boulder Creek, 2 September 1975, Zanoni 2892 (CS). According to Zanoni (pers. comm.) seed of this species was included in a general mix used for local rehabilitation.

Range Extensions

Ipomopsis roseata **(Rydberg) V. Grant**

Moffat Co.: 3 miles north of Sunbeam, 25 May 1938, Brown s.n. (CS). This site represents a range extension of approximately 100 miles north-northeast of the principal distribution in Colorado National Monument.

Lysimachia thyrsiflora **L.**

Larimer Co.: Wet ground along Poudre River, 23 June 1893, Cowen s.n. (CS). Known previously only from a single site in Colorado near Estes Park (Weber, 1976) this species still occurs as sporadic individuals near the crossing of the Poudre River and Highway 14 on the eastern limits of Ft. Collins.

Malacothrix torreyi **A. Gray**

Montrose Co.: Naturita, 15 May 1914, Payson 303 (RM); Garfield Co.: Rifle, 25 June 1900, Osterhout 2150 (RM); Eagle Co.: McCoy, 14 June 1903, Osterhout 2758 (RM). This species is treated as rare and occurring only in Mesa and Delta Counties (Weber and Johnston 1976). The specimens cited above indicate a wider distribution in western Colorado.

Rhododendron albiflorum **Hooker**

Jackson Co.: Lake Katherine, Park Range, 3,000 m, 26 August 1976, Wilken and Painter 12752 (CS); 11 July 1977, Wilken, Painter and Tabar 13178 (CS). Previously known in Colorado only from the headwaters of the South Fork Elk River in Routt Co., this second site represents a range extension east of the continental divide. The population at Lake Katherine is extensive and comprises the dominant understory beneath *Abies lasiocarpa* and *Picea engelmannii.* Based on specimens at MONT and MONTU, the Colorado populations represent a disjunction of approximately 500 miles southeast of the nearest known sites in western Montana.

Ribes americanum **Mill.**

Larimer Co.: Wet seeps along the Poudre River, 20 May 1977, Budzinski s.n. (CS). Known previously only from Roxborough Park in Douglas Co. (Weber, 1976), this species occurs in local abundance near the crossing of the Poudre River and Highway 14 at the present limits of Fort Collins.

Salix candida **Fluegge**

Larimer Co.: 1.5 miles south of the confluence of the Laramie River and Two and One Half Creek, 8,920 ft, 15 July 1974, Phillips 85 (CS). This site represents the second record for *Salix candida* in Colorado, formerly known only from South Park in Park Co.

Literature Cited

Harrington, H. D. 1954. Manual of the plants of Colorado. Denver: Sage Books.

Weber, W. A. 1976. Rocky Mountain flora. Boulder: Colorado Associated University Press.

Weber, W. A., and B. C. Johnston. 1976. Natural history inventory of Colorado. 1. Vascular plants, lichens and bryophytes. Boulder: University of Colorado Museum.

Welsh, S. L., and J. A. Erdman. 1964. Annotated checklist of the plants of Mesa Verde, Colorado. Brigham Young University Sci. Bull. Biol. Series 4(4):1–32.

A COMPARATIVE ANALYSIS OF THE DIATOM FLORA ON THE SNAIL *AMPULLARIA CUPRINA* FROM THE GOSHEN PONDS, UTAH

Larry L. St.Clair[1], Lorin E. Squires[1,2],
and Samuel R. Rushforth[1]

Abstract.— Seventeen genera and 60 species of diatoms were identified from four different substrates in a warm spring-fed pond near Goshen, Utah. The diatom forms sampled included both plankton and periphyton. A minimum of 400 individuals were counted from each sample. Diversity and similarity indices were calculated, and substrate relationships were identified on their basis.

Diatoms have long been known to grow on a wide variety of substrates and in a highly diversified range of habitats. Just such a range of distribution has been observed to occur in the Intermountain West, where diatom research during the last seven years has revealed over 700 species of diatoms in many different aquatic and terrestrial ecosystems.

During the period between April 1973 and April 1975, the diatom flora of the Goshen ponds and wet meadows, Utah County, Utah (a series of warm, spring-fed ponds), was under investigation (St. Clair and Rushforth 1977). Periodically during this study, several large specimens of *Ampullaria cuprina* (mystery snail) were collected from the site designated "Lower Pond." A dense growth of algae colonized the shells of these organisms. In May 1974, several large specimens of this snail were collected and taken to the laboratory in order to identify and characterize the attached algal flora. The present paper treats the diatom species identified from the shell of the snail and compares diatom communities on the snail to planktonic, epiphytic, and epilithic communities in the lower pond.

Materials and Methods

In early May 1974, four substrates in the Lower Goshen Pond were sampled. The plankton was sampled by filtering pond water through a 67-μm mesh plankton net and concentrating it in a 30-ml vial attached to the net. Periphyton on the vegetable material in the pond was sampled by collecting various reeds, grasses, and filamentous algae from the pond. Several rocks from the bottom of the pond were scraped in order to obtain epilithic diatoms. Finally, two specimens of *Ampullaria cuprina* (mystery snail) were collected. All samples were taken to the laboratory, and the diatoms were cleaned using acid oxidation methods (St. Clair and Rushforth 1976). Cleaned frustules were dried on cover slips and subsequently mounted in Naphrax mountant.

Diatoms were identified and counted using a Zeiss RA microscope with Nomarski interference phase-contrast accessories and a 100x oil immersion objective. A minimum of 400 individual diatoms were counted per sample to obtain relative density information for each species.

Diversity and similarity indices were calculated using an IBM 360 model 5 computer in order to obtain community structure information for each substrate. The diversity index was calculated using a program based on the formula

$$\bar{d} = -\sum_{i}^{s} (Ni/N) \operatorname{Log}_2 (Ni/N)$$

in which S = the number of species, Ni = the number of individuals in species i, and

---

[1] Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602.

[2] Present address: Vaughn Hansen Associates, Waterbury Plaza, Suite A, 5620 South 1475 East, Salt Lake City, Utah 84121.

N = the total number of individuals in S species (Cairns and Dickson 1971, Wilhm and Dorris 1968).

This formula is independent of sample size and gives an index which is high when many species are evenly represented in the community and low when most of the individuals occur in only a few species.

The similarity index was calculated from Ruzicka's (1958) formula:

$$SI = \frac{\sum_i \min(x_i, y_i)}{\sum_i x_i + \sum_i y_i - \sum_i \min(x_i, y_i)}$$

in which xi and yi = relative density for the ith species in the two samples being compared. This index gives a quantitative measure of the similarity between two stands of data.

RESULTS

The diatom flora from the four sites included 17 genera and 60 species (Table 1). Of these, 12 genera and 40 species were found on the snail, 11 of the species being unique to the snail's shell. The 5 most common species (Table 2) comprised 61.7 percent of the diatom flora from the snail's shell. The remaining species had relative densities below 4.2 percent, and 20 species were below 1 percent.

A comparison of the diatom communities from the four habitats suggested some general relationships. The rock and vegetable substrates had fewer total species and lower diversity (Table 3) than occurred in the plankton or on the snail shells. The lowest diversity occurred on the vegetable substrate, which appeared to be the most specialized habitat of the four. It also had the least similarity to the other habitats (Fig. 1). *Achnanthes minutissima* was the diatom best adapted to the vegetative habitat, comprising 59 percent of the flora. The higher diversity and total number of species in the plankton and snail samples were due to instability in these habitats.

Instability in the plankton environment was caused by surface turbulence and the upswelling of subterranean water. As a result, many benthic diatoms were present in the plankton. The similarity of the rock and plankton habitats (Fig. 1) indicates that the influx of epilithic diatoms into the plankton was considerable.

Instability in the diatom community on the snail shell was probably a result of the

TABLE 1. Phylogenetic listing of diatom species identified in this study (The species identified with an asterisk were collected from the snail's shell).

ORDER RHIZOSOLENIALES
- *Terpsinoe musica*

ORDER FRAGILARIALES
- *Fragilaria brevistriata* var. *inflata**
- *Fragilaria capucina* var. *mesolepta**
- *Fragilaria construens**
- *Fragilaria construens* var. *venter**
- *Fragilaria crotonensis**
- *Synedra delicatissima**
- *Synedra incisa**
- *Synedra pulchella* var. *lacerata**
- *Synedra tabulata**
- *Synedra ulna**
- *Synedra ulna* var. *contracta**

ORDER EUNOTIALES
- *Eunotia curvata**

ORDER ACHNANTHALES
- *Cocconeis pediculus*
- *Cocconeis placentula* var. *lineata**
- *Achnanthes bottnica**
- *Achnanthes exigua* var. *heterovalva**
- *Achnanthes exigua*
- *Achnanthes lanceolata* var. *dubia*
- *Achnanthes lanceolata**
- *Achnanthes linearis**
- *Achnanthes minutissima**
- *Rhoicosphenia curvata*

ORDER NAVICULALES
- *Anomoeoneis vitrea*
- *Diploneis elliptica*
- *Navicula cryptocephala* var. *veneta*
- *Navicula dicephala**
- *Navicula mutica**
- *Navicula pelliculosa**
- *Navicula perpusilla**
- *Navicula pupula*
- *Navicula pupula* var. *rectangularis*
- *Navicula radiosa*
- *Navicula tripunctata**
- *Navicula* sp. 1*
- *Navicula* sp. 2
- *Navicula* sp. 3
- *Pinnularia viridis**
- *Entomoeoneis alata*
- *Amphora coffeaeformis*
- *Amphora ovalis**
- *Amphora ovalis* var. *pediculus**

*Amphora veneta**
*Cymbella affinis**
*Cymbella cistula**
*Cymbella delicatula**
Cymbella laevis
*Cymbella ventricosa**
Cymbella sp.*
Gomphonema angustatum
*Gomphonema constrictum**
*Gomphonema gracile**
*Gomphonema intricatum**
*Gomphonema parvulum**

Order Epithemiales
*Denticula elegans**

Order Nitzschiales
Nitzschia denticula
Nitzschia dissipata
*Nitzschia frustulum**
Nitzschia frustulum var. *perminuta**
Nitzschia palea

snail's motility. The shell is conducive to diatom attachment and growth, and, as the snail moves among the aquatic vegetation and stony substrate, it becomes seeded with diatoms which occur in these habitats. The continuous movement creates instability by causing frequent removal and addition of diatom frustules, thus preventing the dominance of any one species and providing for colonization of a wider variety of species than commonly occurs on a single stationary substrate. For this reason the diatom flora on the snail's shell had higher diversity and lower similarity to the rock sample than might be expected.

A more complete and replicated sampling program is planned to further investigate

Table 2. Diatom species with relative density above 5 percent in at least one habitat.

	Vegetative	Snail	Rock	Plankton
Achnanthes exigua var. *heterovalva*	1.4	11.0	7.7	8.3
Achnanthes minutissima	59.0	20.0	36.6	24.5
Cymbella delicatula	.4	1.1	11.7	1.5
Fragilaria brevistriata var. *inflata*	2.1	7.5	7.9	3.9
Fragilaria construens	.7	8.2	7.0	5.1
Fragilaria construens var. *venter*	.2	15.0	3.9	3.9
Fragilaria crotonensis	16.2	.9	3.6	11.2
Synedra ulna	5.2	2.2	2.7	2.9

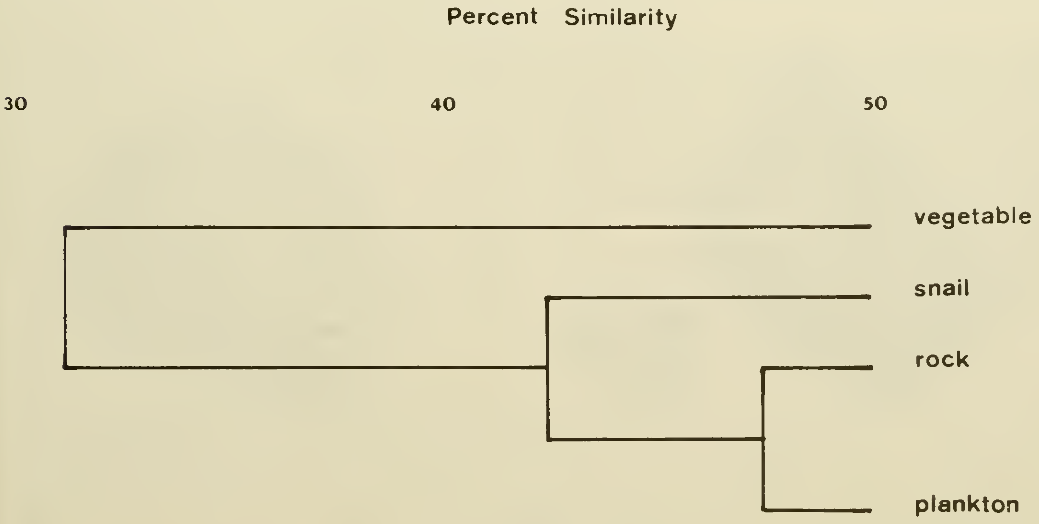


Fig. 1. Cluster dendrogram showing similarity of diatom communities from plankton, vegetable, snail, and rock substrates. Similarity indices were computed on the basis of relative density for diatom species.

the differences and relationships which exist in the plankton, rock, snail, and vegetable habitats of Lower Goshen Pond.

TABLE 3. Shannon Weaver diversity index for diatom communities from four habitats in Lower Goshen Pond.

Sample	Diversity Index	Total Species
Vegetative	2.42	31
Snail	4.07	40
Rock	3.34	29
Plankton	3.82	36

LITERATURE CITED

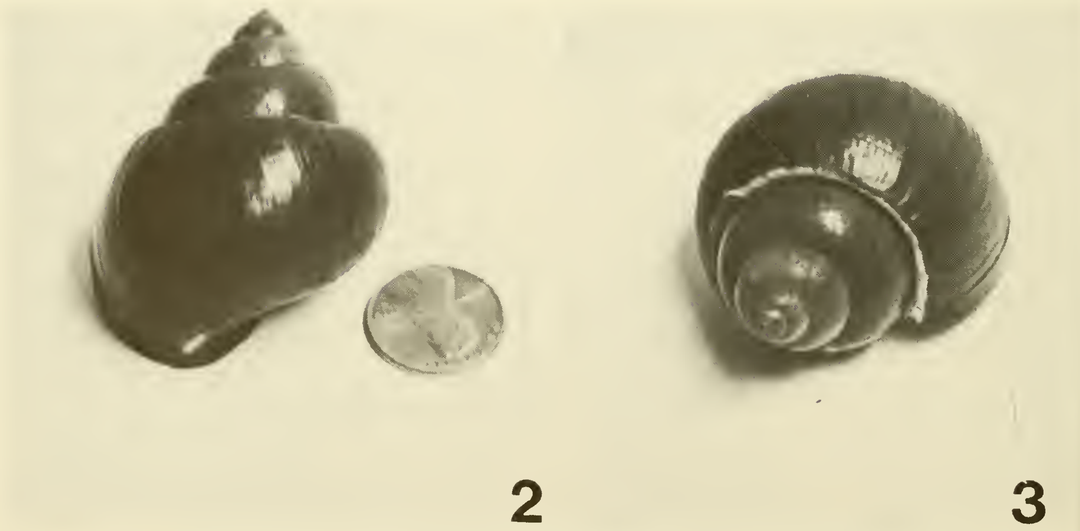
CAIRNS, J., AND K. L. DICKSON. 1971. A simple method for the biological assessment of the effects of waste discharges on aquatic bottom-dwelling organisms. JWPCF 43(5):755–772.

RUZICKA, M. 1958. Anwendung mathematisch-statistischer methoden in der geobotanik (synthetisch e bearbeitung von aufnahmen). Biologia, Bratisl., 13, 647–661.

ST. CLAIR, L., AND S. RUSHFORTH. 1976. The diatoms of Timpanogos Cave National Monument, Utah. American J. Botany 63(1):49–59.

______. 1977. The diatom flora of the Goshen warm spring ponds and wet meadows, Goshen, Utah, USA. Nova Hedwigia XXVIII 28(2–3):353–425.

WILHM, J. L., AND T. C. DORRIS. 1968. Biological parameters for water quality criteria. Bioscience 18(6):477–481.



Figs. 2-3. Representative specimens of *Ampullaria cuprina* (Mystery snail).

GROWTH OF *DIPODOMYS ORDII* (RODENTIA: HETEROMYIDAE)[1]

H. Duane Smith[2], Gary H. Richins[3],
and Clive D. Jorgensen[2]

Abstract.— Growth rates were determined for laboratory-reared *Dipodomys ordii pallidus* Durrant & Setzer. Instantaneous growth rates were used to express increase of body weight, total length, tail length, ear length and hind foot length as rates between times of measurements and the instantaneous percentage of maximum size. Data were analyzed for growth periods of 1–3, 4–15, 16–29 and 30–70 days. All five parameters provided significant correlations of growth with age during all growth periods. Even though all of the growth parameters correlate with age, these parameters cannot be reliably used to predict age.

Dipodomys ordii is one of the most widely distributed small mammal species in North American deserts (Hall and Kelson 1959) and as such occupies a vital position in the bioenergetics of desert ecosystems. Their total role within the ecosystem is not clear, but as primary consumers, they provide an important part of the prey base for higher trophic levels. With increased emphasis being placed on predictive capabilities of productivity within ecosystems, it is desirable to know the potential input of all components. Biomass estimates of rodent populations are often calculated but seldom include estimates for animals below trappable age. *Dipodomys ordii* is no exception. Omission of these types of data is understandable because such data are difficult to obtain, particularly in the field. They are usually provided by laboratory studies, and since *D. ordii* has proven difficult to breed and rear in captivity (Morse et al., in press), no data of consequence have been reported for this species.

Growth rates have been reported for several small mammals (For example, Meyer and Meyer 1944, Pournelle 1952, Chew and Butterworth 1959, Layne 1959, Goertz 1965, Hayden and Gambino 1966, Lackey 1967, Jones 1967, Horner and Taylor 1968, Richins et al. 1974, Lackey 1976, and others). These data have aided in understanding productivity, but data on *D. ordii* are unavailable. The objectives of this study were to characterize growth rates of individual *D. ordii* from birth to 70 days of age and to provide a data base for predictive purposes in ecosystem management.

Methods

The initial specimens of *Dipodomys ordii pallidus* Durrant & Setzer used in this work were live-trapped on the Desert Range Experimental Station, 81 km W of Milford, Millard Co., Utah. Additional animals were obtained from Dugway Proving Grounds, Tooele Co., Utah, and Pahvant Butte, Millard Co., Utah. The laboratory colony was housed at Brigham Young University and maintained at about 85 females and 15–20 males.

Animals were caged individually in glass aquaria or in galvanized metal boxes with sand substrate (about 6.0 cm deep). Nest cans with cotton batting were provided. Water and a food mixture of one part each of sunflower seeds, rolled oats, and pigeon mix were supplied *ad libitum*. Temperature ranged from 20 to 25 C, and the photoperiod was manually graduated to simulate a twilight period.

---

[1] This study was supported in part by the US-IBP Desert Biome studies, contracted from Utah State University with Brigham Young University.

[2] Department of Zoology, Brigham Young University, Provo, Utah 84602.

[3] Wildlife Biologist, Burns and McDonnel, Kansas City, Missouri.

Sexes were kept separate except when mating was attempted. Females were checked daily for the external morphologic changes in the vulva that Pfeiffer (1960) described as indicators of estrous. The full flowered vulvar condition was presumed to indicate estrous. At this time a male was introduced into the female's cage. Males were selected for breeding based on the extent of testicular enlargement. Usually, fighting ensued; if the male survived the first few minutes, he was left with the female for 3–4 days. After this period he was returned to a cage with other males. Females were checked for vaginal plugs as an indication of successful coitus.

After litters were born they were not disturbed until the following day, at which time the young were toe clipped and measured. Body weight, total length, tail length, ear length and hind foot length measurements were taken daily from days 1–29 and then weekly through the remainder of 10 weeks. After eyes of the young opened and individuals became more active, they were anesthetized with Penthrane (Abbott Laboratories, North Chicago, Illinois) to facilitate handling and obtaining accurate measurements.

The instantaneous relative growth rate (IGR) described by Brody (1945) and Lackey (1967) was used to express growth as a rate between times of measurements and the instantaneous percentage of maximum size. This rate is expressed as $(dW/dt)/W$, where W is the parameter measured at the instant the rate of change dW/dt is measured. Since it is not entirely possible to develop the "instantaneous" rate of growth, it was necessary to integrate the infinite number of growth rates to derive $W = Ae^{kt}$. This may be conveniently rewritten as—

$$\ln W_{t-1} = \ln A_t + kt$$

where lnW = natural logarithm of the variable (W), lnA = natural logarithm of the variable (A) and k represents the instantaneous relative growth rate (when multiplied by 100, k = percentage growth rate). For comparative purposes, the representative IGR (k) is determined with—

$$k_n = \frac{\ln W_n - \ln W_{n-1}}{t_n - t_{n-1}}$$

Thus, k is definitive and can be used to compare differences in rates of growth. Correlation coefficients were calculated between age and growth for the five growth variables studied.

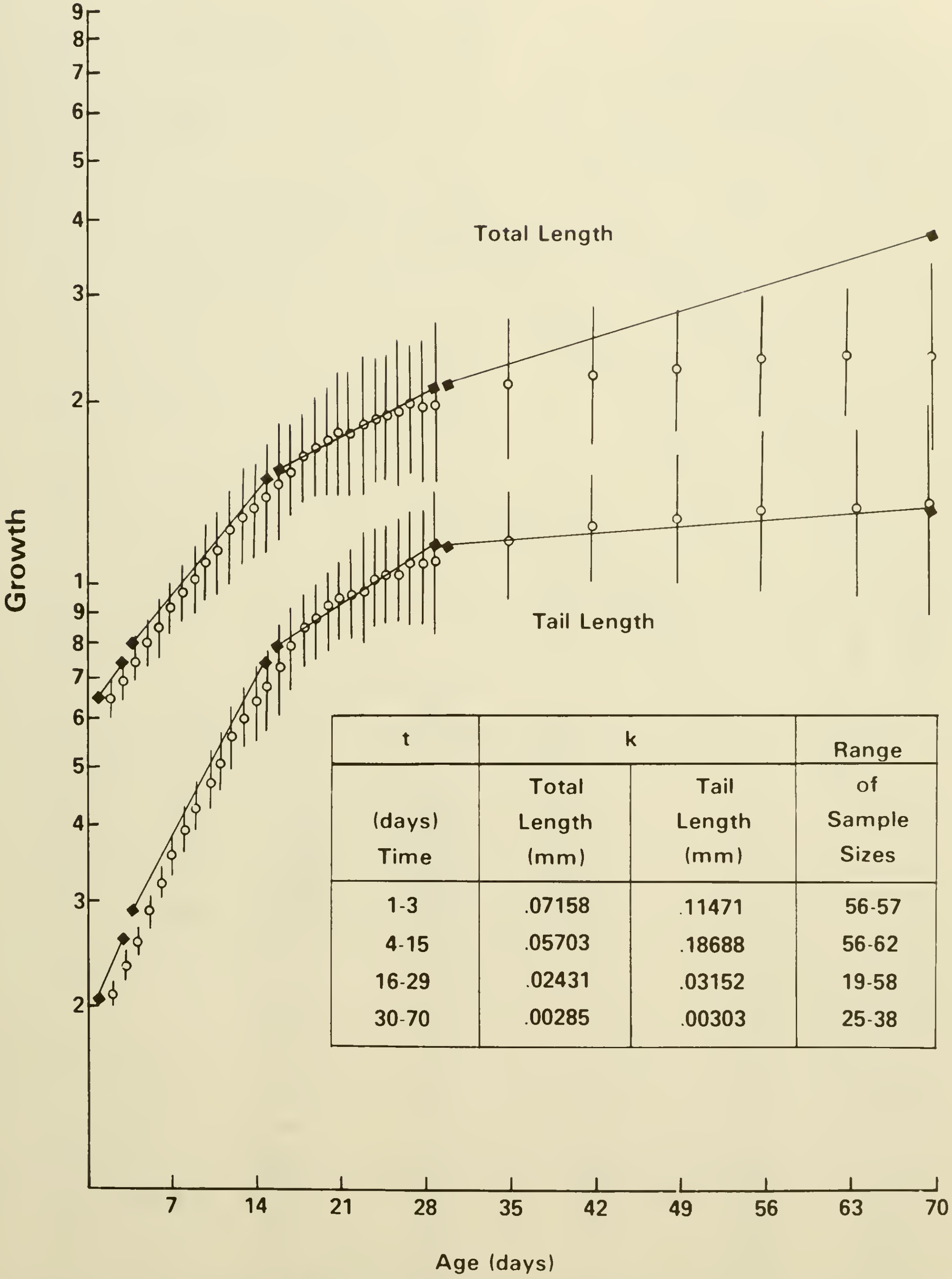
RESULTS

Growth Rates.— Rates of growth along with the instantaneous relative growth rates (k) were determined and are presented for body weight, total length, tail length, ear length and hind foot length (Figs. 1 and 2 and Table 1). When the variables are plotted on a log scale (Figs. 1 and 2), the comparative values of (k) for the growth periods from days 1–70 are illustrated. These results depict growth for animals reared under standardized laboratory conditions and analyzed for time growth periods of 1–3, 4–15, 16–29 and 30–70 days. Other growth periods were graphed and analyzed but these represent the most statistically accurate analyses of *D. ordii* growth.

The R^2 values (Table 1) indicate how much variation is accounted for in the analyses, and when converted to r they can be used to determine statistical significance ($a = 0.05$). A significant r suggests a correlation between the appropriate lnW (log of the variable) and the age of the growing animals when time is partitioned into growth periods.

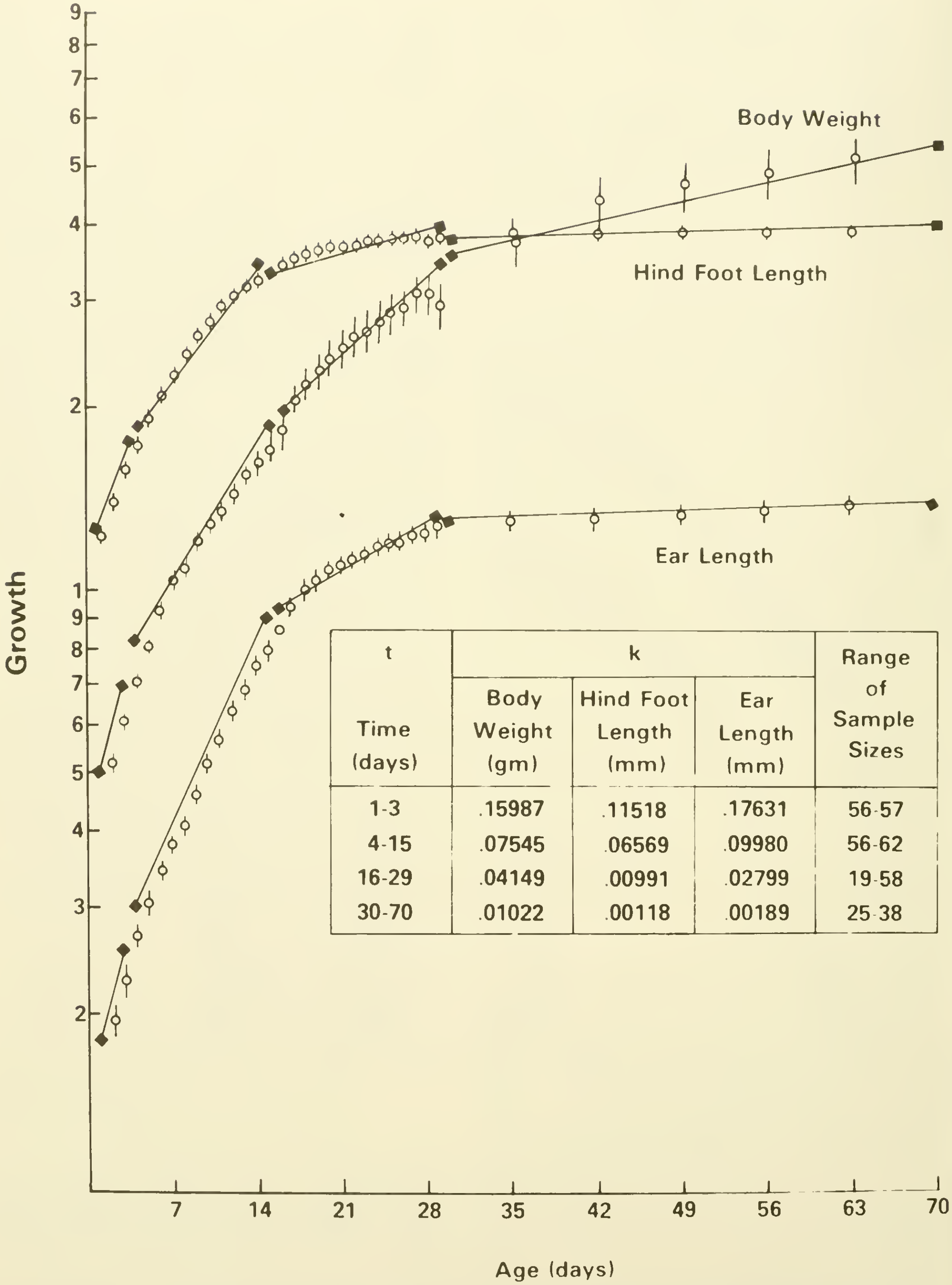
All parameters provided significant correlations of growth with age, because r was significant for all growth periods. No individual parameter consistently provided data with the highest significance throughout all growth periods. The significance levels of all parameters are similar for any given growth period; therefore, it is possible to use any of the parameters as an indicator of growth.

Often researchers are more comfortable working with data means ($\bar{X}$) than with statistics like lnW and k. Because an understanding of the relationship of lnW and $\bar{X}$ is important in an interpretation of k, means and standard errors of the growth parame-



t	k		Range
(days) Time	Total Length (mm)	Tail Length (mm)	of Sample Sizes
1-3	.07158	.11471	56-57
4-15	.05703	.18688	56-62
16-29	.02431	.03152	19-58
30-70	.00285	.00303	25-38

Fig. 1. Means, standard errors (P = 0.95), and growth rates for total length and tail length of *Dipodomys ordii* reared under standardized laboratory conditions. Growth is expressed in standard measurements described in the text.



t	k			Range of Sample Sizes
Time (days)	Body Weight (gm)	Hind Foot Length (mm)	Ear Length (mm)	
1-3	.15987	.11518	.17631	56-57
4-15	.07545	.06569	.09980	56-62
16-29	.04149	.00991	.02799	19-58
30-70	.01022	.00118	.00189	25-38

Fig. 2. Means, standard errors (P = 0.95), and growth rates for body weight, ear length, and hind foot length of *Dipodomys ordii* reared under standardized laboratory conditions. Growth is expressed in standard measurements described in the text.

ters are compared to the k values for curves (Figs. 1 and 2). Curves for k and $\bar{X}$ are almost identical for all parameters measured, but the confidence intervals of the means for total length and tail length are wider for all growth periods.

Since correlations of growth parameters with age were always significant, one might consider using these parameters to predict age. This procedure is important to an evaluation of the population age structure. Although the process seems evident and convenient, since it would simply involve reading the predicted age from a graph, the results cannot be interpreted with statistical confidence because variation among days is lacking. Calculations of confidence limits about the regression line also present problems; the X axis (age) is a nonrandom variable selected by the investigator. Thus, only the regression of Y on X can be estimated with confidence. It is possible that nonparametric procedures could be utilized to provide predictive capabilities (Dapson and Irland 1972).

Discussion

Ideally, growth data should be collected under field conditions, but the difficulty of such collection for animals below trappable age causes biologists to revert to the laboratory where organisms can be confined and environmental influences controlled. The growth data analyzed for *D. ordii* are for animals grown under standardized laboratory conditions simulating mean temperatures and photoperiods encountered by animals during active periods of growth in western deserts. Although all R^2 values were significant (when converted to r) at the P = 0.95 level, one must consider two constraints in their interpretations: (1) the size of n, which when too large reduces the usefulness of r, and (2) the percentage of the variation that must be accounted for before significant correlations are considered biologically acceptable and k is accepted as a reliable estimate of the instantaneous relative growth rate. When the growth curves (Figs. 1 and 2) are examined, the correla-

Table 1. Summary of analyses for growth of *Dipodomys ordii pallidus* reared under standardized laboratory conditions.

Parameter	lnA	Antilog of lnW	Age in Days ($t = t-1$)	R^2	Correlation Coefficient (r)*
Total length	4.09464	74.44	1–3	0.29843	0.54628*
	4.15655	149.90	4–15	0.79170	0.88977*
	4.65890	210.61	16–29	0.49748	0.70532*
	5.27545	237.46	30–70	0.28872	0.53732*
Tail length	2.92560	23.31	1–3	0.21841	0.46734*
	3.02929	75.18	4–15	0.76737	0.87597*
	3.87084	117.92	16–29	0.40309	0.63489*
	4.68195	132.95	30–70	0.12449	0.35283*
Body weight	1.47177	7.03	1–3	0.25465	0.50462*
	1.80782	18.73	4–15	0.64611	0.80380*
	2.33647	34.12	16–29	0.44996	0.67079*
	3.29270	55.15	30–70	0.60571	0.77827*
Ear length	0.45680	2.66	1–3	0.23211	0.48177*
	0.71373	9.03	4–15	0.82902	0.91050*
	1.79442	13.20	16–29	0.58465	0.76461*
	2.48377	13.73	30–70	0.20396	0.45161*
Hind foot length	2.40433	16.64	1–3	0.33954	0.58270*
	2.61515	36.23	4–15	0.81333	0.90184*
	3.37601	38.86	16–29	0.39367	0.62743*
	3.59137	39.24	30–70	0.16730	0.40902*

*Significant at a = .05

tions (r) and comparisons of k with the data means and standard errors seem precise within the prescribed growth periods. One is thus inclined to be rather liberal in setting lower limits on R^2 and accepting the curves as representing the actual growth of *D. ordii* for the time intervals under the controlled conditions. It was determined that $R^2 \geq 0.25$ should provide enough accountability to accept significant correlations and to realistically represent the growth rates. This does not mean that the k values for those analyses with $R^2 < 0.25$ are in error; it means the confidence is not as strong, and caution should be exercised in using these data for actual growth in modeling and predictive situations.

Total body weight is perhaps the most interesting of all parameters measured. It determines biomass and relates to secondary production. Because there are such close relationships between the antilogs of lnW and means, and because there are such narrow confidence limits about the means, antilogs of lnW, means, and k values for body weight should accurately represent the instantaneous relative growth rates for periods up to 70 days of age. Therefore, body weight can be used to predict biomass of animals prior to trappable age. Beyond 70 days the correlations of body weight with age become less reliable, but, because the animals are now trappable and have reached adult size, their productivity can be measured in the field. After 70 days, a close correlation is not necessary because k shows very little increase as evidenced by the body weight curves (Fig. 2). Although the growth rates were obtained under standardized laboratory conditions, they can be considered generally representative for the growth periods prescribed. These growth periods include times when the animals are undergoing normal active growth. Following this time period, weight varies in response to environmental stresses and changes rather than actual growth phenomena.

One possible weakness of these analyses is an inability to assess k under field conditions. Originally, it was assumed that shifts in k under field conditions would not differ significantly from those established in the laboratory, but analyses of data obtained while experimenting with independent variables (photoperiod, temperature and food) for *Peromyscus maniculatus* suggest that this assumption may not be valid. Manipulation of photoperiod, temperature, and food caused k to vary for growth of *P. maniculatus,* but the k values only varied early in the growth period. By the time the animals reached trappable age k values for body weight, regardless of the independent variable changes, were similar. It is possible that interactions of the variables might compensate for one another and reflect no change in k. If so, estimates of biomass could still be made by correlating body weight with age.

There have been several attempts to correlate weight with age and other parameters (Brody 1945, Dapson and Irland 1972 and others) but, because many of them attempted to predict age, the results were not particularly satisfying. Calculation of confidence limits about the regression line is not possible because the X axis (age) is a nonrandom variable, selected by the investigator. This study was concerned more with the characterization of growth as far as weight was concerned. Attempts to age organisms should be done with parameters other than body weight, such as dried eye lens weight or perhaps with tyrosine content of lenses (Dapson and Irland 1972).

LITERATURE CITED

BRODY, S. 1945. Time relations of growth of individuals and populations. *In*: Bioenergetics and Growth. N.Y.: Reinhold, 1023 pp.

CHEW, R. M., AND B. B. BUTTERWORTH. 1959. Growth and development of Merriam's kangaroo rat, *Dipodomys merriami*. Growth 23:75–96.

DAPSON, R. W., AND J. M. IRLAND. 1972. An accurate method of determining age in small mammals. J. Mamm. 53:100–106.

GOERTZ, J. W. 1965. Sex, age, and weight variation in cotton rats. J. Mamm. 46:471–477.

HALL, E. R., AND K. R. KELSON. 1959. The mammals of North America. New York: Ronald Press, 2 Vol., 1083 pp.

HAYDEN, P., AND J. J. GAMBINO. 1966. Growth and development of the little pocket mouse, *Perognathus longimembris*. Growth 30:187–197.

Horner, B. E., and J. M. Taylor. 1968. Growth and reproductive behavior in the southern grasshopper mouse. J. Mamm. 49:644–660.

Jones, C. 1967. Growth, development, and wing loading in the evening bat, *Nycticeius humeralis* (Rafinesque). J. Mamm., 48:1–19.

Lackey, J. A. 1967. Growth and development of *Dipodomys stephensi.* J. Mamm. 48:624–632.

———. 1976. Reproduction, growth and development in the Yucatan deer mouse, *Peromyscus yucatanicus.* J. Mamm. 57:638–655.

Layne, J. A. 1959. Growth and development of the eastern harvest mouse, *Reithrodontomys humulus.* Bull. Florida State Mus., Biol. Sci. 4(2):61–82.

Meyer, B. J., and R. K. Meyer. 1944. Growth and reproduction of the cotton rat, *Sigmodon hispidus hispidus,* under laboratory conditions. J. Mamm. 33:1–20.

Morse, E. L., H. D. Smith, and C. D. Jorgensen. A laboratory breeding of *Dipodomys ordii.* Encyclia (in press).

Pfeiffer, E. W. 1960. Cyclic changes in the morphology of the vulva and clitoris of *Dipodomys.* J. Mamm. 41:43–48.

Pournelle, G. H. 1952. Reproduction and early postnatal development of the cotton mouse, *Peromyscus gossypinus gossypinus.* J. Mamm. 33:1–20.

Richins, G. H., H. D. Smith, and C. D. Jorgensen. 1974. Growth and development of the western harvest mouse *Reithrodontomys megalotis megalotis.* Great Basin Nat. 34:105–120.

SIMILARITY BETWEEN PRONGHORN AND MULE DEER FECAL PELLETS

Mark K. Johnson[1,2] and James G. MacCracken[1]

Abstract.— Botanical compositions and pH values for pronghorn (*Antelocapra americana*) and mule deer (*Odocoileus hemionus*) fecal pellets from the Idaho National Engineering Laboratory Site were different. As there was no overlap between ranges of the herbivores' fecal pH values, the fecal pH technique is a valuable tool for distinguishing between fecal pellets of pronghorn and mule deer on the study area.

Pronghorn (*Antelocapra americana*) and mule deer (*Odocoileus hemionus*) fecal pellets are similar in appearance. On some ranges fecal pH values of pronghorn and mule deer did not overlap and it was concluded that pH analysis of fecal groups was a legitimate method for distinguishing between the two herbivores for one study area (Howard, J. Wildl. Manage. 31(1):190–191). Differences in diet and physiology are possible explanations for differences in fecal pH's (Nagy and Gilbert, J. Wildl. Manage. 32(4):961–962).

The Idaho National Engineering Laboratory (INEL) Site occupies about 231,500 ha (894 mi^2) of southcentral Idaho and contains a large number of pronghorn and a small population of mule deer of unknown size. We were studying pronghorn food habits using botanical analysis of feces and realized that some of our pronghorn samples might have been contaminated with those of mule deer. The purpose of this paper is to report our findings as to differences between pH values and botanical composition for mule deer and pronghorn fecal pellets from the INEL Site. This research was supported in part by the INEL Ecology Project, U.S. Department of Energy, under contract EY-76-S-07-1526 with Colorado State University.

Mule deer pellets were collected in three areas of the INEL Site where deer were located. Although we did not observe deer depositing pellets which were collected, deer were observed on several occasions in the areas. To our knowledge, no pronghorn had been observed in the areas by any persons for at least several weeks. Since the pellets collected were fresh, we were convinced that they were from mule deer. From each area where deer pellets were collected, they were composited into one sample. From three other portions of the study area herbivore pellets were collected which usually bore closer resemblance to mule deer pellets than to pronghorn pellets. Since the identities of these pellets were unknown, they were called unknown Artiodactyl pellets and were analyzed separately. A composite sample was made for each area sampled. Pronghorn pellets were sampled from 24 areas of the INEL Site, and a composite sample was made for each area. Pronghorn pellets were collected in conjunction with an INEL pronghorn ecology study. All pellets used in this study were collected after pronghorn were observed depositing them. Mule deer and unknown Artiodactyl pellets were collected in October 1977. Pronghorn pellets were collected during January, February, and March 1976, July 1976, and July 1977.

Fifty pellets were selected from each composite sample and were ground together in a Wiley Mill over a 1.0 mm mesh sieve.

---

[1] Department of Range Science, Colorado State University, Fort Collins, Colorado 80521.

[2] Present Address: Department of Wildlife and Fisheries, P.O. Drawer LW, Mississippi State University, Starkville, Mississippi 39762.

The botanical composition of each mixture was determined by the method reported by Sparks and Malecheck (J. Range Manage. 21(4):264–265). Similarity in botanical compositions between samples was estimated using Kulczynski's formula (Oosting 1956. The study of plant communities., W. H. Freeman Co. p. 104). One hundred microscope slides were examined for each mixture. Ten different pellets were selected at random from pronghorn, mule deer, and unknown Artiodactyl samples for pH analysis. Each pellet was ground in a Wiley Mill over a 1.0 mm mesh sieve and was soaked in 50 ml of deionized water for one hr. The pH was determined with a Sargent-Welch DG recording titrator. Students' tests were used to compare mean pH values among the different classes of pellets.

Botanical compositions of pronghorn and unknown Artiodactyl pellets were about 65 percent similar (Table 1). Botanical composition of mule deer pellets were only about 25 percent similar to pronghorn or unknown Artiodactyl fecal pellets. *Artemisia*, *Astragalus*, and *Sphaeralcea*, plus *Atriplex*, made up more than 70 percent of the plant fragments in pronghorn pellets, and *Artemisia* and *Astragalus*, plus *Sphaeralcea*, made up more than 70 percent of the plant fragments in unknown Artiodactyl pellets. *Kochia* and *Bromus*, plus *Leptodactylon*, made up more than 70 percent of the plant fragments in mule deer pellets. *Kochia* alone made up more than 50 percent of plant fragments in these pellets. *Kochia* and *Bromus* are common only along roadsides on the INEL Site, where deer had been observed feeding on these plants.

The average (±SE) pH value for mule deer pellets (9.12±0.03: range, 9.05–9.22) was significantly higher ($p<0.05$) than averages for pronghorn (8.60±0.04: range, 8.52–8.72) and unknown Artiodactyl (8.53±0.06: range, 8.38–8.70) pellets, which were similar. The range in pH values from the latter two herbivore classes overlapped, but neither overlapped with the range of pH values from mule deer pellets.

The range in pH values for pronghorn pellets was very narrow, regardless of area or collection date, and range in pH values for mule deer pellets was narrow regardless of area. The major food of pronghorn was *Artemisia* for all collection dates, but *Ceratoides* made up more than 65 percent of three composite samples. The pH values for these samples were not the highest or the lowest values determined for pronghorn samples. In New Mexico narrow ranges in pH values were found for pronghorn and mule deer pellets collected for a whole

Table 1. Mean percent (±SE) relative particle densities of plant fragments recovered from pronghorn, mule deer, and unidentified Artiodactyl fecal pellets from the Idaho National Engineering Laboratory Site.

Taxa[1]		Pronghorn	Unidentified Artiodactyl	Mule Deer
	No. of Composites Examined =	24	3	3
Artemisia		45.8 ± 1.5	48.9 ± 10.6	18.8 ± 9.3
Astragalus		8.5 ± 3.2	14.8 ± 6.6	2.5 ± 1.1
Sphaeralcea		4.6 ± 2.0	12.2 ± 7.3	3.0 ± 4.7
Atriplex		9.4 ± 4.5		0.7 ± 0.6
Ceratoides		15.0 ± 10.0	0.4 ± 0.4	
Kochia				57.8 ± 22.2
Opuntia		4.2 ± 1.8	5.3 ± 3.7	
Salsola			6.9 ± 5.1	0.3 ± 0.3
Leptodactylon			1.0 ± 0.9	3.8 ± 4.7
Erigeron		2.7 ± 1.5	1.6 ± 1.0	
Bromus		0.4 ± 0.2		10.7 ± 5.6

[1] Other taxa in herbivore fecal pellets identified in trace (<2 percent) amounts were *Sitanion, Koeleria, Sporobolus, Vulpia, Carex, Eriogorum, Crepis, Descurania, Achillea, Lygodesmia, Chrysothamnus, Erysimum, Phlox, Balsamorhiza, Sarcobatus, Convolvulus, Castillija, Chenopodium, Stipa, Aristida, Agropyron, Oryzopsis, Salix*, moss, unclassified grasses, unclassified forbs and arthropods.

year, and there was no overlap in the ranges of pH values found for each species (Howard, J. Wildl. Manage. 31(1):190–191). Evidence suggests that seasonal differences in diets have an insignificant influence on fecal pH's. Differences in fecal pH's between species are probably due to physiological differences rather than dietary differences. Under average circumstances fecal pH's of pronghorn and mule deer probably remain within narrow ranges.

The similarity in pH values and botanical compositions of unknown Artiodactyl pellets with those of pronghorn suggests that the unknown fecal pellets were deposited by pronghorn. We conclude that visual examination of Artiodactyl pellets is inadequate for identifying the animal of their origin. However, fecal pH values of pronghorn and mule deer on the INEL Site appear to be different. Since mule deer pellets that we collected were from a few areas and represented a limited portion of the year, we recommend further study to corroborate our findings before the fecal pH technique is employed in practical application on the INEL Site.

NOTICE TO CONTRIBUTORS

Original manuscripts in English pertaining to the biological natural history of western North America and intended for publication in the *Great Basin Naturalist* should be directed to Brigham Young University, Stephen L. Wood, Editor, *Great Basin Naturalist*, Provo, Utah 84602. Those intended for the *Great Basin Naturalist Memoirs* should be similarly directed, but these manuscripts are not encumbered by a geographical restriction.

Manuscripts. Two copies of manuscripts are required. They should be typewritten, double spaced throughout on one side of the paper, with margins of at least one inch on all sides. Use a recent issue of either journal as a format, and the *Council of Biology Editors Style Manual, Third Edition* (AIBS 1972) in preparing the manuscript. An abstract, about 3 percent as long as the text, but not exceeding 200 words, written in accordance with Biological Abstracts guidelines, should precede the introductory paragraph of each article. Authors may recommend one or two reviewers for their article. All manuscripts receive a critical peer review by specialists in the subject area of the manuscript under consideration.

Manuscripts that are accepted and that are less than 100 printed pages in length will automatically be assigned to the *Great Basin Naturalist.* Those manuscripts larger than 100 printed pages in length will be considered for the *Memoirs* series.

Illustrations and Tables. All illustrations and tables should be made with a view toward having them appear within the limits of the printed page. Illustrations that form part of an article should accompany the manuscript. Illustrations should be prepared for reduction by the printer to either a single-column (2 5/8 inches) or double-column (5 1/2 inches) width, with the length not exceeding 7 1/2 inches.

Costs Borne by Contributor. Contributors to the *Great Basin Naturalist* should be prepared to donate from $10 to $30 per printed page toward publication of their article (in addition to reprint costs outlined in the schedule below). Authors publishing in the *Great Basin Naturalist Memoirs* may be expected to contribute $35 per printed page in addition to the cost of printed copies they purchase. No printed copies are furnished free of charge. A price list for reprints and an order form are sent with the galley proof to contributors.

Reprint Schedule of the *Great Basin Naturalist*

	2 pp.	4 pp.	6 pp.	8 pp.	10 pp.	12 pp.	Each additional 2 pp.
100 copies	$20	$24	$28	$32	$36	$40	$4
200 copies	28	32	36	40	44	48	
300 copies	36	40	44	48	52	56	

Great Basin Naturalist Memoirs

No. 1 The birds of Utah. By C. L. Hayward, C. Cottam, A. M. Woodbury, H. H. Frost. $10.

No. 2 Intermountain biogeography: A symposium. By K. T. Harper, J. L. Reveal, et al. $15.

TABLE OF CONTENTS

Kaiparowits flora. Stanley L. Welsh, N. Duane Atwood, and Joseph R. Murdock.... 125

Range extension of *Onychomys torridus longicaudus* (Rodentia: Cricetidae) in northwestern Nevada. Mark D. Engstrom and Eugene D. Fleharty................ 180

The reproductive ecology of the Tahoe sucker, *Catostomus tahoensis*, in Pyramid Lake, Nevada. Joseph L. Kennedy and Paul A. Kucera................................... 181

Primary productivity in meromictic Big Soda Lake, Nevada. R. P. Axler, R. M. Gersberg, and L. J. Paulson.. 187

Current status of cutthroat trout subspecies in the western Bonneville Basin. Terry J. Hickman and Donald A. Duff.. 193

Reproductive biology of the tui chub, *Gila bicolor*, in Pyramid Lake, Nevada. Paul A. Kucera.. 203

Distributional records for the Colorado flora. D. Wilken, W. Harmon, C. Feddema, and H. Harrington.. 208

A comparative analysis of the diatom flora on the snail *Ampullaria cuprina* from the Goshen Ponds, Utah. Larry L. St. Clair, Lorin E. Squires, and Samuel H. Rushforth.. 211

Growth of *Dipodomys ordii* (Rodentia: Heteromydiae). H. Duane Smith, Gary H. Richins, and Clive D. Jorgensen.. 215

Similarity between pronghorn and mule deer fecal pellets. Mark K. Johnson and James G. MacCracken.. 222

THE GREAT BASIN NATURALIST

Volume 38 No. 3 September 30, 1978 Brigham Young University

MUS. COMP. ZOOL.
LIBRARY

JAN 19 1979

HARVARD
UNIVERSITY

GREAT BASIN NATURALIST MEMOIRS

Editor. Stephen L. Wood, Department of Zoology, Brigham Young University, Provo, Utah 84602.

Editorial Board. Kimball T. Harper, Botany; Wilmer W. Tanner, Life Science Museum; Stanley L. Welsh, Botany; Clayton M. White, Zoology.

Ex Officio Editorial Board Members. A. Lester Allen, Dean, College of Biological and Agricultural Sciences; Ernest L. Olson, Director, Brigham Young University Press, University Editor.

The *Great Basin Naturalist* was founded in 1939 by Vasco M. Tanner. It has been published from one to four times a year since then by Brigham Young University, Provo, Utah. In general, only previously unpublished manuscripts of less than 100 printed pages in length and pertaining to the biological natural history of western North America are accepted. The *Great Basin Naturalist Memoirs* was established in 1976 for scholarly works in biological natural history longer than can be accommodated in the parent publication. The *Memoirs* appears irregularly and bears no geographical restriction in subject matter. Manuscripts are subject to the approval of the editor.

Subscriptions. The annual subscription to the *Great Basin Naturalist* is $12 (outside the United States $13). The price for single numbers is $4 each. All back numbers are in print and are available for sale. All matters pertaining to the purchase of subscriptions and back numbers should be directed to Brigham Young University, Life Science Museum, Provo, Utah 84602. The *Great Basin Naturalist Memoirs* may be purchased from the same office at the rate indicated on the inside of the back cover of either journal.

Scholarly Exchanges. Libraries or other organizations interested in obtaining either journal through a continuing exchange of scholarly publications should contact the Brigham Young University Exchange Librarian, Harold B. Lee Library, Provo, Utah 84602.

Manuscripts. All manuscripts and other copy for either the *Great Basin Naturalist* or the *Great Basin Naturalist Memoirs* should be addressed to the editor as instructed on the back cover.

11-78 650 35893

ISSN 0017-3614

The Great Basin Naturalist
Published at Provo, Utah, by
Brigham Young University

ISSN 0017-3614

Volume 38 September 30, 1978 No. 3

UTAH FLORA: FABACEAE (LEGUMINOSAE)

Stanley L. Welsh[1]

Abstract.— A revision of the legume family, Fabaceae (Leguminosae), is presented for the state of Utah. Included are 244 species and 60 varieties of indigenous and introduced plants. A key to genera and species is provided, along with detailed descriptions, distributional data, and pertinent comments. Proposed new taxa are *Astragalus lentiginosus* Dougl. ex Hook, var. *wahweapensis* Welsh; *Astragalus subcinereus* A. Gray var. *basalticus* Welsh; *Hedysarum occidentale* Greene var. *canone* Welsh; *Oxytropis oreophila* A. Gray var. *juniperina* Welsh; and *Trifolium andersonii* A. Gray var. *friscanum* Welsh. New combinations include *Astragalus bisulcatus* (Hook.) A. Gray var. *major* (M. E. Jones) Welsh; *Astragalus consobrinus* (Barneby) Welsh; *Astragalus pubentissimus* Torr & Gray var. *peabodianus* (M. E. Jones) Welsh; *Lathyrus brachycalyx* Rydb. var. *zionis* (C. L. Hitchc.) Welsh; *Lathyrus lanzwertii* Kellogg var. *arizonicus* (Britton) Welsh; *Lathyrus langwertii* Kellogg var. *laetivirens* (Greene) Welsh; *Lupinus argenteus* Pursh var. *moabensis* (Dunn & Harmon) Welsh; *Lupinus argenteus* Pursh var. *rubricaulis* (Greene) Welsh; *Lupinus caudatus* Kellogg var. *argophyllus* (A. Gray) Welsh; *Lupinus caudatus* Kellogg var. *cutleri* (Eastw.) Welsh; *Lupinus pusillus* Pursh var. *rubens* (Rydb.) Welsh; *Lupinus sericeus* Pursh var. *barbiger* (S. Wats.) Welsh; *Lupinus sericeus* Pursh var. *marianus* (Rydb.) Welsh; *Oxytropis besseyi* (Rydb.) Blankinship var. *obnapiformis* (C. L. Porter) Welsh; *Psoralea lanceolata* Pursh var. *stenostachys* (Rydb.) Welsh.

This paper is the second in a series of works leading to a definitive treatment of the flora of Utah. The first paper dealt with the Brassicaceae (Great Basin Nat. 37: 279–365. 1977). The legume family, with 304 taxa, is one of the largest present in the state, apparently ranked second after the Asteraceae, but in third place following the Poaceae if only the 244 specific taxa are counted. Adventive plants account for 45 species, or about 15 percent of the total taxa in the family. This is fewer than the 18 percent determined for the Brassicaceae. Weedy species represent only a small proportion of the adventive taxa; the bulk consists of cultivated crop and ornamental plants. More than half of the 45 legume genera in Utah are known from introduced plants. The 24 introduced genera account for only 30 species, however. It seems unlikely that other large families will be represented by such a large percentage of adventive genera. The remainder of the introduced species are in genera with indigenous species in Utah.

The largest genus of legumes, and probably of any plant family in Utah, is *Astragalus* with 110 species and 36 varieties. This genus has long proved troublesome to taxonomists, partly because of its great size, and partly because of the complex nature of some species.

The definitive treatment by Dr. Rupert C. Barneby provides a basis for understanding of *Astragalus*, and this treatment is dedicated to him. Generally, the specific and infraspecific lines are rather sharply drawn, but in the *Astragalus lentiginosus* complex taxa apparently grade through series of morphological intermediates. Some

---

[1] Department of Botany and Range Science, and Life Science Museum, Brigham Young University, Provo, Utah 84602.

30 taxa within *Astragalus*, almost a quarter of the total, are endemic to Utah often on highly specialized soil types. The currently proposed lists of endangered or threatened plants are replete with *Astragalus* taxa.

It is difficult to find a portion of Utah where one or more species of *Lupinus* are not present. Annual species are more common at lower elevations, but some occur at middle and even upper elevations. Specific lines are more easily drawn among annual species. Perennials occur as complex groups which tend to intergrade in endless entanglements. Because of these problems, species lines have been subject to interpretation, and only the careful work of Dr. David Dunn and his students has allowed meaningful interpretation of Utah lupine materials.

Oxytropis is less complex in Utah than elsewhere, primarily due to the low number of species and to the geographical isolation of taxa known to hybridize elsewhere. Only *O. oreophila* exhibits a wide spectrum of variation in the state.

Trifolium consists of both indigenous and introduced species which are markedly distinct, both morphologically and geographically. The Old World introductions listed are among our most important forage plants.

The legume family is economically important because of utilization of plants as food for man and animals. Some representatives are poisonous and have harmed livestock in the state. These are noted within the text.

Perhaps the most economically important crop derived from this family is alfalfa or lucern *(Medicago sativa)*. Thousands of acres are planted to this forage crop in Utah.

The writer follows the example found in Barneby (1964, Atlas of North American *Astragalus*) in citing the number of specimens of each species examined. The numbers follow the discussion of each taxon, with the Arabic numerals indicating the total number seen and the Roman numerals the number collected by me.

FABACEAE Lindley
Legume Family

Herbs, shrubs, or trees; leaves alternate, pinnately or palmately compound, or simple, stipulate; flowers perfect, irregular or regular, usually borne in racemes; calyx 5-lobed; petals 5 (a banner, 2 wings, and 2 keels) or fewer, less commonly reduced to 1 (banner), or lacking; stamens 10 or 5, or numerous, diadelphous, monadelphous, or distinct; pistil 1, the ovary superior, 1- or 2-loculed, 1-carpelled, the style and stigma 1; fruit (pod) a legume or loment, sessile, subsessile, stipitate, or with a gynophore, dehiscent or indehiscent.

REFERENCES

ISELY, D. 1973. Leguminosae of the United States: I. Mimosoideae. Mem. N.Y. Bot. Gard. 25(1): 1–52.

______. 1975. Leguminosae of the United States: II. Caesalpinoideae. Mem. N.Y. Bot. Gard. 25(2): 1–228.

WELSH, S. L. 1963. Legumes of Utah I. Preliminary report. Proc. Utah Acad. 40: 200–201.

______. 1964. Legumes of Utah II. Conspectus of the genera. Proc. Utah Acad. 41: 84–86.

1. Flowers regular, in dense heads or compact spicate racemes; stamens numerous (Mimosoideae) .... Key I

— Flowers irregular (only slightly so in some); stamens 10 or fewer 2

2(1). Corolla not papilionaceous, sometimes nearly regular, the upper petal enclosed by the others; stamens 10 or fewer, commonly distinct (Caesalpinoideae) .... Key II

— Corolla papilionaceous, the upper petal (banner) enclosing the wing and keel petals in bud, much reduced in *Amorpha*, or lacking in *Dalea, Psorothamnus*, and *Parryella*; stamens 10 or 5 (Papilionideae) 3

3(2). Plants woody; trees, shrubs, or woody vines .... Key III
— Plants herbaceous perennials or annuals 4

4(3). Leaves even-pinnate .... Key IV
— Leaves odd-pinnate or simple 5

5(4). Leaflets 3 only .... Key V
— Leaflets 5 or more, or the leaves simple .... Key VI

KEY I

Flowers regular: stamens numerous (Mimosoideae)

1. Trees, unarmed, cultivated; flowers in umbellate heads; stamens long-exserted, the filaments commonly 20–30 mm long .... *Albizia*
— Trees or shrubs, armed, indigenous; flowers in spicate racemes; stamens included or shortly exserted, the filaments less than 5 mm long 2

2(1). Spines recurved; pods flat, 10–20 mm broad, brown at maturity .... *Acacia* (*greggii*)
— Spines straight; pods spirally coiled or if flattened then less than 10 mm broad and yellowish to tan at maturity .... *Prosopis*

KEY II

Corolla not papilionaceous (Caesalpinoideae)

1. Plants herbaceous perennials; flowers yellow; indigenous to southeastern Utah .... *Hoffmanseggia*
— Plants trees or shrubs; flowers variously colored; indigenous or introduced 2

2(1). Leaves simple, the blades rotund-ovate; flowers pink, appearing before the leaves .... *Cersis*
— Leaves once or twice compound; flowers yellow, white, or greenish, appearing after the leaves 3

3(2). Shrubs; flowers with yellow petals, the exserted stamens to 50 mm long or more; cultivated and naturalized in Washington Co. .... *Caesalpinia*
— Trees; flowers with white or greenish-yellow petals, the stamens included or not much exserted; distribution broad 4

4(3). Leaves once to twice pinnate; branches often armed; flowers greenish-yellow, borne in spicate racemes; pods long and strap-shaped .... *Gleditsia*
— Leaves bipinnate; branches unarmed; flower white, long-stalked, in open panicles; pods thick .... *Gymnocladus*

KEY III

Trees, shrubs, or woody vines (Papilionideae)

1. Leaves even-pinnate, the rachis produced apically as a bristle; flowers yellow .... *Caragana*
— Leaves simple or odd-pinnate; flowers variously colored 2

2(1). Leaves simple or the lower ones 3-foliolate; plants shrubs; flowers yellow; solitary or borne in erect racemes 3
— Leaves compound; plants varying in one or more ways from above 4

3(2). Calyx split above hence 1-lipped, with 5 minute teeth; flowers borne in erect racemes; Washington Co. .... *Spartium*

— Calyx bilabiate, the upper lip 2-lobed, the lower 3-lobed; flowers mostly solitary axillary; Weber Co. .... *Cytissus*

4(2). Plants twining woody vines; flowers large and showy, borne in terminal, pendulous racemes .... *Wisteria*

— Plants trees or shrubs; flowers various, usually borne in axillary, erect or pendulous racemes 5

5(4). Leaflets 3; flowers yellow, borne in pendulous racemes .... *Laburnum*

— Leaflets 5 or more; flower white, pink, indigo, or yellow, borne in erect or spreading racemes 6

6(4). Herbage glandular-punctate; indigenous shrubs with petals indigo or lacking 7

— Herbage not glandular-punctate; cultivated or indigenous shrubs or trees; petals white, pink, or yellow, or if indigo (as in *Amorpha*) then the corolla reduced to a single petal (the banner) 8

7(6). Petals lacking; leaflets linear; plants of Grand and San Juan Co. .... *Parryella*

— Petals present; leaflets broad; plants of southern and southeastern Utah .... *Psorothamnus*

8(6). Petals 1, the banner only present, indigo; sparingly cultivated shrubs .... *Amorpha*

— Petals 5, white, pink, or yellow; shrubs or trees, sparingly to commonly cultivated 9

9(8). Plants shrubs; pods bladdery-inflated; flowers yellow; ornamental and roadside plants .... *Colutea*

— Plants trees or shrubs; pods flat or terete; flowers white or pink 10

10(9). Branches armed with stipular spines or internodal hispid processes; staminal filaments diadelphous; petals pink or white .... *Robinia*

— Branches unarmed; staminal filaments distinct; petals white 11

11(10). Leaf bases hollow, covering superposed buds; pods flat, not constricted between the seeds .... *Cladrastis*

— Leaf bases solid, not covering buds; pods terete, constricted between the seeds .... *Sophora*

Key IV

Leaves even-pinnate (Papilionideae)

1. Flowers yellow; fruit ripening below ground, tardily dehiscent, constricted between the seeds .... *Arachis*

— Flowers white, pink, red, lavender, or cream; fruit borne above ground, not constricted between the seeds 2

2(1). Style strongly dilated; sepals foliaceous; plants cultivated .... *Pisum*

— Style not strongly dilated; sepals not foliaceous; plants indigenous or cultivated 3

3(2). Style bearded down one side; wings of corolla essentially free from the keel . ... *Lathyrus*

— Style bearded in a tuft or ring at apex; wings of corolla adherent to the keel .... *Vicia*

KEY V
Leaflets three (Papilionideae)

1. Leaves palmate, the terminal leaflet neither stalked nor jointed 2

— Leaves pinnate, the terminal leaflet stalked or jointed 4

2(1). Flowers golden-yellow, the banner orbicular, large; legumes narrowly oblong, erect or ascending; staminal filaments distinct .... *Thermopsis*

— Flowers ochroleucous to white or pink to pink-purple, the banner not orbicular, moderate to small in size; staminal filaments diadelphous 3

3(2). Leaflets usually toothed; flowers mostly in heads, commonly pink or white .... *Trifolium*

— Leaflets entire; flowers not in heads, commonly ochroleucous or pink .... *Astragalus*

4(1). Herbage glandular-punctate; indigenous plants with usually linear to oblanceolate leaflets .... *Psoralea*

— Herbage not glandular-punctate; indigenous or cultivated plants with spatulate to obovate or oblanceolate to ovate leaflets 5

5(4). Leaflets entire 6

— Leaflets toothed (except in some *Trifolium* species) 8

6(5). Flowers in umbels, loosely capitate, or solitary in leaf axils, yellow or suffused with orange .... *Lotus*

— Flowers in interrupted racemes or panicles, purplish 7

7(6). Leaflets stipellate; pods several seeded, several to many times longer than broad .... *Phaseolus*

— Leaflets lacking stipels; pods 1-seeded, only somewhat longer than broad .... *Lespedeza*

8(5). Flowers usually in heads; corolla persistent, investing the fruit; fruit straight .... *Trifolium*

— Flowers usually in racemes; corolla not persistent; fruit straight or curved to coiled 9

9(8). Leaflets toothed along the distal ½ or more; racemes elongate, several times longer than broad .... *Melilotus*

— Leaflets toothed along the distal ⅓ only (except in some *Trigonella*); racemes compact or loose, seldom more than twice longer than broad 10

10(9). Fruit straight or falcately curved, prominently veined on the valves; flowers yellow; terminal leaflet with an apical spinose cusp, rarely as much as twice longer than broad; plants rare .... *Trigonella*

— Fruit coiled or curved, veined or not; flowers pink, lavender, whitish, or yellow; terminal leaflet seldom strongly cuspidate apically, usually more than twice longer than broad; plants common .... *Medicago*

Key VI

Leaflets (4) 5 or more, or simple (Papilionideae)

1. Leaves palmately compound, with usually 5–11 leaflets, long-petiolate 2

— Leaves pinnately compound, or if rarely palmately compound (as in some *Lotus* species), then sessile or with only 4 leaflets 3

2(1). Herbage glandular-dotted; leaflets usually 5, broadly obovate-spatulate; stamens usually diadelphous; pods 1-seeded .... *Psoralea*

— Herbage not glandular-dotted; leaflets usually 7–11, variously shaped; stamens monadelphous; pods several-seeded .... *Lupinus*

3(1). Herbage glandular-dotted 4

— Herbage not glandular-dotted 5

4(3). Racemes spicate; legumes 1-seeded, not bearing appendages; stamens 5; petals (except banner) inserted on staminal tube .... *Dalea*

— Racemes not spicate; legumes several-seeded, bearing hooked appendages; stamens 10; petals not inserted on staminal tube .... *Glycyrrhiza*

5(3). Terminal leaflet of lower leaves several times larger than the lateral; inflorescence of many-flowered head closely subtended by foliose involucral bracts; flowers yellow; introduced, rare .... *Anthyllis*

— Terminal leaflet not much larger than the lateral; inflorescence a raceme or an umbel, lacking foliose bracts (except in *Lotus*); flower color various 6

6(5). Margin of leaflets toothed; corolla persistent, investing the fruit .... *Trifolium*

— Margin of leaflets entire; corolla usually deciduous 7

7(6). Flowers in umbels, loosely capitate, or solitary in leaf axils; petals yellow, often suffused with orange, or pink 8

— Flowers in racemes or cymes; petals usually not yellow 9

8(7). Leaflets 3–5; flowers yellow .... *Lotus*

— Leaflets 9–23; flowers pink to pink-purple .... *Coronilla*

9(7). Keel petals much longer than the wings; fruit a flattened loment 10

— Keel petals subequal to the wings or shorter; fruit a legume (a terete loment in *Sophora*) 11

10(9). Fruit 4- to several-seeded, not spiny (except in *H. boreale* var. *gremiale*); plants indigenous .... *Hedysarum*

— Fruit 1- to 2-seeded, more or less spiny-toothed; plants adventive, cultivated and escaping .... *Onobrychis*

11(9). Stipules spiny; flowers dirty whitish .... *Peteria*

— Stipules various, but not spiny; flowers seldom if ever dirty whitish 12

12(11). Staminal filaments distinct; fruit a terete to somewhat flattened loment; plants with blue or white flowers, usually of sandy sites .... *Sophora*

— Staminal filaments diadelphous or monadelphous; fruit a legume; plants from a caudex and/or taproot, rarely rhizomatous; habitats various 13

13(12). Keel with a porrect beak; ventral suture of legume forming a partial or complete partition; plants usually acaulescent .... *Oxytropis*

— Keel beakless, or the beak diverging from the floral axis; ventral suture usually not produced internally, the dorsal usually produced in bilocular fruits; plants usually caulescent 14

14(13). Stamens monadelphous; flowers blue .... *Galega*

— Stamens diadelphous; flowers pink-purple, pink, lavender, ochroleucous, red, white, or variously suffused, but not blue 15

15(14). Flowers red-orange when fresh; plants adventive .... *Sphaerophysa*

— Flowers pink, pink-purple, lavender, or white to ochroleucous; plants indigenous, or rarely adventive .... *Astragalus*

ACACIA P. Miller

Armed trees; leaves alternate, often clustered on short axillary shoots, bipinnate, petiolate, the pinnae bearing several leaflets; internodal spines curved; stipules small and deciduous; flowers numerous, borne in elongate spikes; calyx 5-lobed; corolla regular, 5-lobed, inconspicuous; stamens numerous, included, distinct; ovary substipitate; pods flattened, indehiscent.

Acacia greggii **A. Gray.** Catclaw Acacia. Small trees to 4 m tall, the branches armed with curved internodal spines; leaves to about 4 cm long, with 2 pairs of pinnae, each with 4–6 pairs of obovate to oblong leaflets 3–6 mm long, puberulent on both surfaces; petioles 2–5 mm long, bearing a solitary gland between the lower pair of pinnae; spikes mostly 3–6 cm long (including peduncles); flowers fragrant, 2–2.5 mm long; petals greenish, like the sepals; legumes flattened, oblong, usually curved, 50–100 mm long, 10–20 mm wide, constricted between the seeds; seeds 5–7 mm broad, nearly circular. Warm desert shrub, drainage-terrace vegetation, at about 870 m in Washington Co.; Nevada, California, Arizona, New Mexico, Texas, and Mexico. Our material belongs to var. ***arizonica*** **Isely.**

ALBIZIA Durazzini

Unarmed trees; leaves alternate, not clustered, bipinnate, petiolate, the several pairs of pinnae each with numerous oblique leaflets; stipules small and caducous; flowers several to many, in umbellate heads; calyx tubular, 5-lobed; corolla united, funnelform, the 5 lobes shorter than the tube; stamens numerous, united into a tube basally, long-exserted; pods flattened, dehiscent.

Albizia julibrissin **Durazzini.** Silk-tree, Mimosa. Small tree to 3 m tall or more and as broad or broader; leaves to 25 cm long or more (including petiole), with 5–10 (15) pairs of pinnae, each with 12–25 (30) pairs of leaflets 7–15 mm long, puberulent, if at all, on rachis and leaflet margins; petioles 3–6 cm long, each with a single large flattened gland; calyx 3–3.5 mm long; corolla 7.5–9.5 mm long, cream to greenish; staminal filaments exserted 20–30 mm, brightly rose-pink to reddish in color; pods 120–200 mm long, 15–25 mm wide, oblong, flattened, membranous. Cultivated ornamental at lower elevations in much of Utah, but frost sensitive; introduced from Asia.

AMORPHA L.

Cultivated shrubs; leaves alternate, odd-pinnate, the leaflets marked with dots, usually with stipels; flowers purple, borne in terminal spicate racemes; calyx 5-toothed, persistent; banner present (wings and keel lacking), wrapped around the stamens and style; stamens 10, monadelphous at the base only, otherwise distinct; pods 1- to 2-seeded, tardily dehiscent.

1. Plants usually less than 1 m tall; petioles short, usually shorter than width of lowest leaflets .... *A. canescens*

— Plants usually more than 1 m tall; petioles elongate, longer than the width of the lowest leaflets .... *A. fruticosa*

Amorpha canescens **Pursh.** Lead Plant. Subshrub, the erect branches, mostly 4–10 dm tall, the herbage densely white-villous; leaves subsessile, 2.5–12 cm long, with 15–51 leaflets, these elliptic to lance-elliptic or oblong, green above, white-hairy beneath; racemes clustered, paniculate; calyx tube white-villous; pods white-villous, the style almost as long as the body. Cultivated ornamental in some communities in northern Utah (Reimschüssel s.n., BRY); introduced from the Great Plains; indigenous from Canada south to Texas and New Mexico.

Amorpha fruticosa **L.** False Indigo, Bastard Indigo. Shrub to 3 m tall or more, the herbage sparingly pubescent to glabrate; leaves long-petioled, with 13–35 leaflets, these elliptic to oblong, green on both sides, the lower only somewhat paler and strigulose; racemes clustered, paniculate; calyx tube glabrous; pods glabrous, the style much shorter than the body. Cultivated ornamental and botanical curiosity in northern Utah (Vickery 1085, 2252, UT); introduced from eastern United States; indigenous in much of eastern North America and southwestward to Arizona.

ANTHYLLIS L.

Cultivated herbaceous perennial; leaves odd-pinnate; stipules small, adnate the petiole, the lowermost somewhat sheathing; flowers many, borne in pedunculate heads or head-like clusters; calyx tubular, 5-lobed; corolla papilionaceous; stamens 10, monadelphous; pods invested by the accrescent calyx, 1- or few-seeded.

Anthyllis vulneraria **L.** Kidney Vetch, Woundwort. Stems arising from a caudex, 8–30 cm tall, decumbent to erect; leaves 2–7 cm long, odd-pinnate, with usually 5–9 leaflets, the terminal leaflet of lowermost leaves much larger than the lateral ones; peduncles 5–16 cm long, usually with a foliose bract below the inflorescence; heads 1 to few, each closely subtended by foliose bracts; flowers 10–15 mm long, sessile, yellow (or suffused with red); calyx pilose, much inflated at maturity. Introduced forage and reseeding plant, known from Sanpete Co. (Stevens 364, BRY), but to be expected elsewhere; indigenous to Eurasia.

ARACHIS L.

Cultivated annual herbs; leaves even-pinnate, lacking tentrils; stipules prominent, long-attenuate, adnate to the petiole and almost sheathing the stem; flowers yellow, papilionaceous, few or solitary in the axils, sessile, hypanthium elongating and pushing developing ovary underground; stamens diadelphous, usually 9 and 1; pods maturing underground, indehiscent, constricted between the seeds.

Arachis hypogaea **L.** Peanut. Stems from a taproot, mostly 20–50 cm tall; leaves mostly 4–15 cm long, even-pinnate, with 2 pairs of leaflets, 2.2–6 cm long, 0.8–2.5 cm wide, entire; stipules 20–35 mm long; flowers yellow, soon withering, usually only the lowermost producing fruits. Sparingly cultivated plants, rarely escaping but not persisting, in Utah; introduced from Brazil (?).

ASTRAGALUS L.

Plants annual or perennial, caulescent or acaulescent, from a taproot, a caudex commonly developed, rarely with a rhizome; leaves alternate, odd-pinnate, trifoliolate, or simple; stipules adnate to the petiole base, sometimes connate-sheathing around the stem; flowers papilionaceous, in axillary racemes, each subtended by a single bract; bracteoles 1 or 2 or lacking, attached at base of calyx or on pedicel; calyx 5-toothed; petals 5, pink, lavender, pink-purple, ochroleucous, or white, or variously suffused, the keel shorter than the wings, rounded to attenuate apically; stamens diadelphous; ovary enclosed in the staminal sheath, the style glabrous; pods variable in size, shape, and dehiscence, unilocular to bilocular, sessile, subsessile, or stipitate (or with a gynophore). Note: This is a large and complex genus, certainly the largest genus of flowering plants in Utah, and because of this, the keys to species are constructed as to reflect political geographic subdivisions of the state. This makes it possible to identify unknown plants without the effort of struggling through a single interminably long key. Keys and descriptions are based on some 3800 specimens from Utah, a quarter of them collected by the author.

REFERENCES

BARNEBY, R. C. 1964. Atlas of North American *Astragalus*. Mem. N.Y. Bot. Gard. 13: 1–199.

JONES, M. E. 1923. Revision of North American species of *Astragalus*. By the Author, Salt Lake City, Utah. 288 pp.

RYDBERG, P. A. 1929. Astragalanae. North American Flora 24: 251–462.

1. Plants of northwestern Utah (i.e., Box Elder, Cache, Davis, Juab, Morgan, Salt Lake, Tooele, Utah, and Weber counties) .... Key I

– Plants not from northwestern Utah 2

2(1). Plants of south-central and southwestern Utah (i.e., Beaver, Iron, Millard, Piute, Sanpete and Sevier counties) .... Key II

– Plants not from south-central and southwestern Utah 3

3(2). Plants of Washington County .... Key III

– Plants not of Washington County 4

4(3). Plants of northeastern Utah (i.e., Daggett, Duchesne, Rich, Summit, Uintah, and Wasatch counties) .... Key IV

– Plants of east-central and southeastern Utah 5

5(4). Plants of Carbon, Emery, and Wayne counties .... Key V

– Plants of Garfield, Grand, Kane, and San Juan counties 6

6(5). Plants of Grand and San Juan counties .... Key VI

– Plants of Garfield and Kane counties .... Key VII

KEY I

Plants of Box Elder, Cache, Davis, Juab, Morgan,
Salt Lake, Tooele, and Weber counties

1. Plants prostrate; leaves to 1 cm long, with spinulose-tipped leaflets all decurrent; usually of high elevations .... *A. kentrophyta*

– Plants of various habit; leaves often more than 1 cm long, not or rarely spinose, the lateral ones usually jointed to the rachis; distribution various 2

2(1). Leaves all simple; plants strictly acaulescent; dwarf, mat-forming plants of high elevations in Cache Co. .... *A. spatulatus*

– Leaves with (3) 5–25 leaflets or more, or only the uppermost simple; plants caulescent or acaulescent, of low to high elevations 3

3(2). Plants rush-like or sprawling, with slender leaflets, or the uppermost leaves often simple, the terminal leaflet confluent with the rachis 4

– Plants not rush-like, the leaflets various but usually not slender and with the uppermost leaves simple, the terminal leaflet jointed to the rachis 8

4(3). Flowers 15–19 mm long; stems arising from a superficial woody caudex 5

– Flowers less than 10 mm long; stems arising from a slender, subrhizomatous, subterranean caudex 6

5(4). Flowers ochroleucous; calyx brown; legumes long-stipitate, pendulous .... *A. lonchocarpus*

— Flowers bicolored, pink-purple with white wing-tips; calyx purplish; legumes sessile, erect ..... *A. toanus*

6(4). Pods bladdery-inflated; pubescence of malpighian (dolabriform) hairs; stems usually sprawling ..... *A. ceramicus*

— Pods oblong, not inflated; pubescence of basifixed hairs; stems erect 7

7(6). Leaflets and leaf rachis commonly expanded into flat, grass-like blades; ovules 10–16; pods mostly 10–17 mm long, 3–3.7 mm broad; plants of moist meadows and streambanks, rare ..... *A. diversifolius*

— Leaflets and leaf rachis usually very narrow; ovules more than 17; pods 25–45 mm long, 2.5–3.3 mm broad; plants of dry hillsides, common ..... *A. convallarius*

8(3). Calyx tube less than 4 mm long, campanulate or short-cylindric 9

— Calyx tube more than 4 mm long, cylindric to long-cylindric 18

9(8). Plants acaulescent, with a distinctive thatch of persistent leaf bases; pods bladdery inflated; dwarf, at high elevations in western ranges, rare ..... *A. platytropis*

— Plants short- to long-caulescent, not with marcescent leaf bases; pods various; of low to high elevations 10

10(9). Plants annual, from slender taproots, usually of low elevation arid sites 11

— Plants perennial, with well-developed caudices; commonly montane 12

11(10). Pods bladdery-inflated, unilocular; flowers 3 or more per raceme; plants of sandy sites ..... *A. geyeri*

— Pods curved-oblong, bilocular or nearly so; flowers often 1 or 2 per raceme; plants of various soils ..... *A. nuttallianus*

12(10). Stipules all distinct, not connate-sheathing around the stem 13

— Stipules connate-sheathing around the stem, at least the lowermost 14

13(12). Pods bladdery-inflated, bilocular; leaflets oblanceolate or broader; flowers pale ..... *A. lentiginosus*

— Pods oblong, not inflated, unilocular; leaflets narrowly oblong; flowers dirty purplish ..... *A. pinonis*

14(12). Pubescence malpighian; pods falcately curved, bilocular ..... *A. falcatus*

— Pubescence basifixed; pods straight, unilocular 15

15(14). Flowers ochroleucous; pods stipitate, either laterally flattened or bisulcate; inflorescence several times longer than broad 16

— Flowers usually some shade of pink or lavender, sometimes as above; pods stipitate or sessile, neither strongly flattened nor bisulcate 17

16(15). Stipules turning black on drying; flowers usually 15 or fewer; pods strongly laterally compressed ..... *A. tenellus*

— Stipules not turning black on drying; flowers usually many more than 15; pods bisulcate ..... *A. bisulcatus*

17(15). Keel with a prominent upturned beak; pods and ovaries sessile, laterally compressed; plants common ..... *A. miser*

— Keel merely rounded apically; pods and ovaries stipitate, 3-angled; plants rare .... *A. alpinus*

18(8). Plants acaulescent or subacaulescent, the internodes seldom apparent, the stems then prostrate; herbage usually grayish-hairy 19

— Plants caulescent, the internodes not obscured by leaf bases and stipules (subacaulescent in *A. megacarpus*); stems usually erect or ascending; herbage commonly green 26

19(18). Wing tips bilobed; plants with malpighian hairs; flowers commonly 12 mm long or less .... *A. calycosus*

— Wing tips entire; pubescence basifixed; flowers usually 15 mm long or more 20

20(19). Plants strictly acaulescent, clothed below with a persistent thatch of leaf bases and stipules 21

— Plants either not strictly acaulescent or the thatch not, or only poorly, developed 22

21(20). Flowers ochroleucous, the keel purple-tipped; pods thinly long-pilose, the valves apparent through the pubescence .... *A. eurekensis*

— Flowers pink-purple throughout; pods densely woolly-villous, the valves obscured by hairs .... *A. newberryi*

22(20). Leaves very densely hirsute-tomentose, with the longer hairs straight and spirally twisted; pods bilocular, densely woolly-hairy .... *A. mollissimus*

— Leaves variously pubescent, but if densely tomentose, the hairs all fine, sinous, and cottony, none straight and spirally twisted 23

23(22). Pubescence of leaves, and commonly of entire plant, softly villous-tomentose, consisting of fine, cottony, contorted or entangled hairs; pods both villous-tomentose and hirsute 24

— Pubescence of leaves various but not of extremely fine entangled hairs; pods merely strigose, or both villous-hirsute and tomentose 25

24(23). Leaflets mostly obovate and obtuse; flowers bright pink-purple .... *A. utahensis*

— Leaflets various, but where the range of this and the preceding overlap (in Box Elder County), either elliptic or the petals whitish .... *A. purshii*

25(23). Pods hirsute and tomentose, the valves obscured by the long hairs; plants uncommon in northwestern Utah .... *A. marianus*

— Pods strigillose to strigose, the valves not obscured by the short hairs; plants common in northwestern Utah .... *A. argophyllus*

26(18). Plants subacaulescent; inflorescences with 1–4 pink-purple flowers, soon surpassed by the leaves; pods unilocular, 25–60 mm long, bladdery-inflated .... *A. megacarpus*

— Plants caulescent; inflorescences with 5 to many ochroleucous to pink-purple flowers, often surpassing the leaves; pods uni- or bilocular, often less than 25 mm long, or flowers not pink-purple, bladdery-inflated or not 27

27(26). Stems arising from slender, rhizome-like caudex branches; flowers subsessile in head-like racemes, erect or ascending; pods erect, long-pilose, less than 12 mm long .... *A. agrestis*

— Stems arising from a woody caudex; flowers variously arranged, but if headlike then commonly spreading; pods various, but if erect then not long-pilose and often over 12 mm long 28

28(27). Pubescence of herbage consisting largely or entirely of malpighian hairs; pods erect, oblong-cylindric, fully bilocular; flowers ochroleucous; plants flowering in June and July .... *A. canadensis*

— Pubescence of herbage consisting of basifixed hairs; pods not as above; flowers variously colored; plants flowering in springtime 29

29(28). Stipules connate-sheathing, at least some 30

— Stipules all distinct 32

30(29). Stems and leaves long-hairy; plants with nodding white flowers; pods pendulous, stipitate, the body narrowly oblong, straight glabrous, bilocular .... *A. drummondii*

— Stems and leaves merely strigose; flowers ochroleucous; pods differing 31

31(30). Pods and ovaries glabrous, the body more than 12 mm long when mature, curved, trigonous, bilocular; plants of foothills and mountains, not with odor of selenium .... *A. scopulorum*

— Pods and ovaries usually strigose, the body often less than 12 mm long when mature, straight, bisulcate, unilocular; plants of low elevations in clay soils .... *A. bisulcatus*

32(29). Flowers small, the banner 12 mm long or less 33

— Flowers larger, the banner 12.5–28 mm long 34

33(32). Pods narrowly lanceolate to lance-elliptic in outline, never inflated, semi-bilocular; plants of western Box Elder Co. .... *A. iodanthus*

— Pods greatly inflated, bilocular; plants of various distribution .... *A. lentiginosus*

34(32). Flowers ochroleucous, or less commonly pink-purple; pods either bladdery-inflated or leathery and dorsiventrally compressed, borne on a stipe-like gynophore (a stalk of receptacular origin), usually jointed to the pod 35

— Flowers pink-purple or bicolored, not or seldom ochroleucous (except in *A. adanus*); pods bladdery inflated or not, sessile or nearly so 36

35(34). Pods bladdery-inflated, 1-loculed, commonly more than 30 mm long, the stipe (gynophore) more than 2 mm long in flower .... *A. oophorus*

— Pods leathery, subunilocular, never bladdery, dorsiventrally compressed, 15–30 mm long, the stipe (gynophore) 2 mm long or less in flower .... *A. beckwithii*

36(34). Flowers ochroleucous; stem and pods erect; plants rare in Utah .... *A. adanus*

— Flowers pink-purple or bicolored; pods usually spreading; plants common to abundant 37

37(36). Flowers usually bicolored, borne in compact racemes; pods oblong in outline, leathery, unilocular .... *A. cibarius*

— Flowers usually pink-purple, borne in short to elongate racemes; pods bladdery-inflated, membranous to papery, bilocular .... *A. lentiginosus*

KEY II

Plants of Beaver, Iron, Millard, Piute,
Sanpete, and Sevier counties

1. Plants mat-forming to erect, with leaflets all spinulose-tipped and decurrent along the rachis ..... *A. kentrophyta*

– Plants various but not with both spinulose tips on leaflets and the leaflets all decurrent 2

2(1). Leaves simple, the blades oval to orbicular ..... *A. asclepiadoides*

– Leaves plurifoliolate, or if some simple then not as above 3

3(2). Plants rush-like or sprawling, the terminal leaflet confluent with the rachis and the upper leaves often simple 4

– Plants various, but seldom rush-like, the terminal leaflet jointed to the rachis and all leaves commonly plurifoliolate 9

4(3). Flowers less than 10 mm long; stems arising from a slender subterranean, subrhizomatous caudex 5

– Flowers 15–20 mm long; stems arising from a superficial caudex 6

5(4). Pods bladdery-inflated; pubescence of malpighian hairs; stems usually sprawling ..... *A. ceramicus*

– Pods narrowly oblong, not inflated; pubescence basifixed; stems erect ..... *A. convallarius*

6(4). Flowers ochroleucous or very pale fresh pink 7

– Flowers pink-purple or bicolored 8

7(6). Racemes commonly shorter than the subtending leaves; calyx not brown; pods sessile, curved; plants in rounded clumps, not especially rush-like ..... *A. tetrapterus*

– Racemes much longer than subtending leaves; calyx brown; pods long-stipitate, pendulous, straight; plants rush-like ..... *A. lonchocarpus*

8(6). Uppermost leaves often simple; flowers bicolored; pods sessile, erect; plants of western Millard County ..... *A. toanus*

– Uppermost leaves usually with tiny leaflets; flowers uniformly pink-purple; pods stipitate, pendulous; plants of Sevier Co. ..... *A. coltonii*

9(3). Plants annual, usually growing in sand; pods bladdery-inflated ..... *A. geyeri*

– Plants perennial, of various soils; pods various 10

10(9). Pubescence of herbage consisting largely or entirely of malpighian hairs 11

– Pubescence of herbage consisting of simple basifixed hairs 15

11(10). Plants acaulescent; stipules all distinct 12

– Plants caulescent; stipules connate, at least those at the lowermost nodes 13

12(11). Wing-tips deeply cleft apically; flowers usually bicolored, or varicolored in populations; pods bilocular, oblong ..... *A. calycosus*

– Wing-tips entire; flowers ochroleucous suffused with purple; pods unilocular, obliquely ovoid; plants of eastern Sevier Co. ..... *A. consobrinus*

13(11). Flowers yellowish; pods erect; plants erect, with odor of selenium .... *A. flavus*

— Flowers pink-purple or ochroleucous; pods ascending; plants spreading, not with odor of selenium 14

14(13). Racemes 1- to 3-flowered; flowers pink-purple; leaflets 7–11; plants rare in Sanpete Co. .... *A. sesquiflorus*

— Racemes 7- to many-flowered; flowers ochroleucous or suffused with dull purple; leaflets 11–17; plants of Beaver and Iron cos. .... *A. humistratus*

15(10). Flowers small, the banner 12 mm long or less 16

— Flowers larger, the banner 12.5–20 mm long or more 29

16(15). Stipules all distinct, not even the lowermost connate 17

— Stipules connate into a sheath, at least at the lowermost nodes 21

17(16). Flowers 5.5–8.5 mm long, bicolored; pods narrowly oblong, 3-angled, stipitate, the stipe 1.4–2 mm long .... *A. straturensis*

— Flowers over 8.5 mm long, or if shorter then not bicolored; pods either bladdery-inflated or sessile, or both 18

18(17). Flowers dull purplish; pods oblong in outline; caudex usually subterranean .... *A. pinonis*

— Flowers ochroleucous to pink-purple; pods bladdery-inflated; caudex superficial 19

19(18). Flowers very small, ochroleucous, the banner 5.2–8 mm long; pods diaphanous, unilocular; plants of the Sevier Valley .... *A. wardii*

— Flowers larger, or purplish, or the pods not especially diaphanous, or else bilocular; plants of various distribution 20

20(19). Pods with a stipe 1–2.5 mm long, unilocular; flowers usually pink-purple; plants of plateaus in Iron and Piute cos. .... *A. serpens*

— Pods sessile, bilocular; flowers ochroleucous tinged purplish; plants mainly of western Beaver and Iron cos. .... *A. lentiginosus*

21(16). Stipules turning black on drying; flowers ochroleucous; pods stipitate, the body strongly laterally flattened .... *A. tenellus*

— Stipules not turning black on drying; flowers variously colored; pods stipitate or sessile, the body not as above 22

22(21). Plants subacaulescent, the internodes obscured by stipules and leaf bases 23

— Plants short- to long-caulescent, the internodes apparent though sometimes short 25

23(22). Flowers ochroleucous; plants of lake shores and ridges in eastern Iron Co. .... *A. limocharis*

— Flowers pink-purple; plants of ridge tops in western Beaver and Sanpete cos. 24

24(23). Leaflets glabrous above; pods unilocular; plants of Sanpete Co. .... *A. montii*

— Leaflets strigose above; pods semibilocular; plants of western Beaver Co. .... *A. platytropis*

25(22). Plants erect or ascending; pods stipitate, pendulous 26

— Plants prostrate to decumbent or erect; pods short-stipitate to subsessile, usually not pendulous 27

26(25). Flowers deflexed, numerous; plants with odor of selenium ..... *A. bisulcatus*

— Flowers ascending to spreading; plants lacking odor of selenium ..... *A. australis*

27(25). Plants high alpine dwarfs with bladdery-inflated pods; known from Tertiary igneous gravels in Piute Co. ..... *A. perianus*

— Plants of high to low elevations, spreading, the pods oblong or merely turgid 28

28(27). Plants erect; keel with an elongate erect beak, pods oblong, not at all inflated ..... *A. miser*

— Plants spreading-decumbent, keel-tip merely rounded; pods inflated ..... *A. subcinereus*

29(15). Plants acaulescent or subacaulescent; herbage grayish or silvery-pubescent 30

— Plants caulescent (except subacaulescent in some *A. megacarpus*); herbage usually green 39

30(29). Plants strictly acaulescent; leaflets 3–11, or flowers 1–6 per raceme, or both; thatch of persistent leaf bases and stipules often obscuring the caudex branches 31

— Plants not strictly acaulescent, or if so then leaflets more than 11, or flowers more than 8, or both; thatch of persistent leaf bases and stipules poorly developed or lacking 33

31(30). Herbage pubescent with malpighian hairs (even though the attachment just above the base); flowers ochroleucous, tinged with purple, the keel purple-tipped; plants local in Piute and Sevier cos. ..... *A. loanus*

— Herbage pubescent with basifixed hairs; flowers ochroleucous or pink-purple, the keel purple-tipped; plants more widely distributed 32

32(31). Petals commonly ochroleucous, sometimes faintly suffused with purple; valves of pod scarcely obscured by curly hairs ..... *A. eurekensis*

— Petals pink-purple; valves of pod obscured by contorted underhairs ..... *A. newberryi*

33(30). Herbage pubescent with malpighian hairs; pods strigose to strigillose; plants of Iron Co. ..... *A. amphioxys*

— Herbage pubescent with basifixed hairs; pods variously pubescent; plants of broad or other distribution 34

34(33). Leaves very densely hirsute with the longer hairs spirally twisted; pods bilocular, densely long-hairy ..... *A. mollissimus*

— Leaves variably pubescent, if densely tomentose, then the hairs all extremely fine, sinuous, and cottony, none straight and spirally twisted; pods unilocular, variously hairy 35

35(34). Pubescence of leaves (and commonly of entire plant) softly villous-tomentose, composed of extremely fine, cottony, or contorted and entangled hairs; pods both villous-tomentose and hirsute ..... *A. utahensis*

— Pubescence of leaves various, composed either of straight, appressed of narrowly ascending hairs, or of spreading-incurved and sometimes sinuous and contorted hairs; pods strigulose, villous, or hirsute 36

36(35). Pods strigose to strigulose, the valves not obscured by the pubescence .... *A. argophyllus*

— Pods hirsute or tomentose or both, the valves usually obscured by the pubescence 37

37(36). Valves of pod hirsute with lustrous hairs, not obscured by the hairs; plants of sandy sites at low elevations in Millard Co. .... *A. callithrix*

— Valves of pods shaggy-hirsute and tomentose, almost or quite concealed by the hairs; plants of various distribution 38

38(37). Leaf pubescence appressed or nearly so; petals not very strongly graduated, the banner 17–21 and the keel 15–19 mm long; pods 20–35 mm long; ovules 27–36; plants widespread .... *A. marianus*

— Leaf pubescence mostly ascending; petals strongly graduated, the banner 18–22.5, the keel 12–13.5 mm long; pods to 12 mm long; ovules 14–16; plants local in Sanpete Co. .... *A. desereticus*

39(29). Plants subacaulescent; inflorescences with 1–4 pink-purple flowers, soon surpassed by the leaves; pods unilocular, 25–60 mm long, bladdery-inflated .... *A. megacarpus*

— Plants caulescent; inflorescences with 5-many ochroleucous to pink-purple flowers, often surpassing the leaves; pods uni- or bilocular, often less than 25 mm long, bladdery-inflated or not 40

40(39). Stems arising from slender, rhizome-like caudex branches; flowers subsessile, in head-like racemes, erect or ascending; pods erect, long-pilose, less than 12 mm long .... *A. agrestis*

— Stems arising from a woody caudex; flowers variously arranged, but if in head-like racemes then usually spreading; pods various but if erect then not long-pilose and often over 12 mm long 41

41(40). Stipules connate into a sheath, at least at the lowermost nodes .... (Note: go to couplet 29, Key I)

— Stipules all distinct 42

42(41). Plants odoriferous selenophytes of claysoils; flowers ochroleucous; pods leathery-woody, cylindric to ovoid, spreading to ascending 43

— Plants not with odor of selenium, of various soils; flowers ochroleucous, pink-purple, or bicolored; pods inflated, often bladdery and membranous, but if leathery then of different shape 44

43(42). Calyx ochroleucous or whitish, as pale as the petals; pods cylindric, steeply ascending; plants of eastern Sevier Co. .... *A. pattersonii*

— Calyx of somewhat different hue from the petals; pods normally spreading-ascending and ellipsoid or broadly cylindric; plants of western Sevier, Millard, Beaver, and Iron cos. .... *A. praelongus*

44(42). Pods and ovaries long-hairy, at maturity plumply ovoid; flowers ochroleucous, steeply ascending; plants introduced in Sanpete Co., but to be expected elsewhere .... *A. cicer*

— Pods and ovaries strigose to glabrous, at maturity variously shaped; flowers ochroleucous, pink-purple, or bicolored, seldom steeply ascending; plants indigenous and widespread 45

45(44). Flowers ochroleucous 46

— Flowers pink-purple or bicolored 47

46(45). Pods bladdery-inflated, unilocular, usually more than 30 mm long at maturity; stipe more than 2 mm long subequal to the calyx tube .... *A. oophorus*

— Pods leathery, subunilocular, never bladdery, dorsiventrally compressed, 15–30 mm long; stipe 2 mm long or less in flower .... *A. beckwithii*

47(45). Flowers bicolored, the wing-tips white, borne in subcapitate racemes; pods oblong, leathery, sessile .... *A. cibarius*

— Flowers pink-purple, borne in open racemes; pods various, but not as above 48

48(47). Pods and ovaries bilocular, sessile or nearly so; plants widespread and common .... *A. lentiginosus*

— Pods and ovaries subunilocular or unilocular, shortly to moderately stipitate; plants of rather restricted range in western Millard, Iron, and Beaver cos. 49

49(48). Pods bladdery-inflated, unilocular, usually more than 30 mm long; stipe subequal to the calyx tube; calyx tube more than 7 mm long .... *A. oophorus*

— Pods leathery, subunilocular, never bladdery, dorsiventrally compressed 15–30 mm long; stipe shorter than the calyx tube; calyx tube less than 7 mm long .... *A. beckwithii*

KEY III

Plants of Washington County

1. Plants rush-like or sprawling, the terminal leaflet confluent with the rachis, and the upper leaves often simple 2

— Plants various, but seldom rush-like, the terminal leaflet jointed to the rachis and all leaves plurifoliolate 5

2(1). Flowers more than 12 mm long, the petals ochroleucous or suffused with pale pink; pods curved, dorsiventrally compressed .... *A. tetrapterus*

— Flowers less than 12 mm long, the petals variously colored; pods neither curved nor dorsiventrally compressed 3

3(2). Pods and ovaries stipitate, at maturity bladdery-inflated; pubescence malpighian; stems from elongated rhizome-like caudex branches .... *A. ceramicus*

— Pods and ovaries sessile or subsessile, oblong in outline, not inflated; pubescence basifixed; stems from superficial to deep-seated caudex 4

4(3). Stipules connate into a sheath, at least at lowermost nodes; plants of northwestern Washington Co. .... *A. convallarius*

— Stipules all distinct; plants of eastern Washington Co. .... *A. lancearius*

5(1). Plants slender, diminutive annuals with tiny flowers and curved bilocular pods .... *A. nuttallianus*

— Plants perennial, and otherwise commonly differing from above 6

6(5). Pubescence of herbage consisting largely or entirely of malpighian hairs 7

— Pubescence of herbage consisting of basifixed hairs 11

7(6). Flowers pink-purple, more than 12 mm long; pods 20–30 mm long or more .... *A. amphioxys*

— Flowers variously colored, but if pink-purple then usually less than 12 mm long or pods shorter than 12 mm long 8

8(7). Plants acaulescent; wing petals deeply cleft apically; pods bilocular .... *A. calycosus*

— Plants with well-developed stems; wing petals entire apically; pods uni- or bilocular 9

9(8). Flowers ochroleucous, nodding at anthesis; pods erect, bilocular, oblong-cylindric .... *A. canadensis*

— Flowers ochroleucous to pink-purple, ascending to anthesis; pods erect to spreading, variously shaped, unilocular 10

10(9). Stems prostrate-spreading; pods curved, not bisulcate ventrally; plants not with odor of selenium .... *A. humistratus*

— Stems erect or ascending; pods straight, bisulcate ventrally; plants with odor of selenium .... *A. flavus*

11(6). Flowers small, the banner 12 mm long or less 12

— Flowers larger, the banner 12.5–25 mm long or more 15

12(11). Flowers 6.5–8.5 mm long, bicolored; pods narrowly oblong, 3-angled, stipitate, the stipe 1.4–2 mm long .... *A. straturensis*

— Flowers over 8.5 mm long, or if shorter then not bicolored; pods bladdery-inflated, sessile or subsessile 13

13(12). Plants subacaulescent, usually less than 5 cm tall; flowers 1–5; rare in sandy sites in eastern Washington Co. .... *A. striatiflorus*

— Plants caulescent, usually over 20 cm tall; flowers numerous; plants of various habitats and distribution 14

14(13). Pods bilocular, diaphanous; lowermost stipules distinct .... *A. lentiginosus*

— Pods unilocular, opaque and usually mottled; lowermost stipules shortly connate-sheathing .... *A. subcinereus*

15(11). Plants acaulescent or subacaulescent; herbage grayish or silvery hairy 16

— Plants caulescent; herbage usually green 22

16(15). Plants strictly acaulescent, the caudex branches obscurred by a thatch of persistent leaf bases; leaflets 11 or fewer .... *A. newberryi*

— Plants subacaulescent, the caudex branches not obscurred by a thatch of leaf bases; leaflets commonly more than 11 17

17(16). Leaflets more than 21 on at least some mature leaves; pods strigose or strigulose .... *A. tephrodes*

— Leaflets fewer than 21 on all leaves, or the pods densely villous 18

18(17). Leaves very densely hirsute with the longer hairs spirally twisted; pods bilocular, densely long-hairy .... *A. mollissimus*

— Leaves variably pubescent, if densely tomentose, the hairs all extremely fine, sinuous, and cottony, none straight and spirally twisted; pods unilocular, variously hairy 19

19(18). Pods densely long hairy 20

— Pods merely strigose or strigulose 21

20(19). Leaflets oval to orbicular, rounded apically, white cottony-hairy; calyx tube more than 4 mm wide (when pressed) .... *A. utahensis*

— Leaflets elliptic to obovate, obtuse or acute to rounded apically, silvery strigose; calyx tube less than 4 mm wide .... *A. marianus*

21(19). Leaflets mostly acute; pods brightly mottled; rocky ledges and talus of sandstone canyons and escarpments .... *A. zionis*

— Leaflets obtuse to acute; pods not mottled; plants mostly of humus in mountain brush and upwards .... *A. argophyllus*

22(15). Stipules connate-sheathing, at least at the lowermost nodes 23

— Stipules all distinct 24

23(22). Petals ochroleucous, the keel purple-tipped; pods pendulous, the body oblong-cylindric, bisulcate; plants with odor of selenium .... *A. bisulcatus*

— Petals pink-purple or ochroleucous; pods erect, the body ovoid, not bisulcate .... *A. ampullarius*

24(22). Plants odoriferous selenophytes, usually of clay soils; flowers ochroleucous or pink-purple with white wing-tips; pods oblong-cylindric, ascending or spreading 25

— Plants not odoriferous selenophytes, of various soils, flowers variously colored; pods various 26

25(24). Flowers bicolored; calyx suffused dark-purple; pods erect-ascending .... *A. preussii*

— Flowers ochroleucous; calyx greenish; pods ascending-spreading .... *A. praelongus*

26(24). Pods and ovaries stipitate, the stipe at maturity subequal to or surpassing the calyx 27

— Pods and ovaries sessile or nearly so 28

27(26). Stems decumbent to ascending; pods bladdery-inflated, unilocular, the body usually over 25 mm long; flowers ochroleucous or pink-purple .... *A. oophorus*

— Stems erect; pods not or only somewhat inflated, bilocular, the body usually less than 20 mm long; flowers ochroleucous or pink-purple .... *A. eremiticus*

28(26). Pods bladdery-inflated, ovoid or merely curved-oblong, bilocular, sessile; flowers variously colored, but not usually bicolored .... *A. lentiginosus*

— Pods not bladdery, oblong, usually curved, bi- or unilocular; flowers commonly bicolored 29

29(28). Flowers borne in subcapitate racemes; pods dorsiventrally compressed, unilocular .... *A. cibarius*

— Flowers borne in elongate racemes; pods laterally or trigonously compressed, bilocular .... *A. ensiformis*

KEY IV

Plants of Daggett, Duchesne, Rich, Summit,
Uintah, and Wasatch Counties

1. Plants mat-forming or erect, with leaflets all spinulose-tipped and decurrent

along the rachis .... *A. kentrophyta*

— Plants various, but not with the leaflets both spinulose-tipped and decurrent on the rachis 2

2(1). Leaves simple, oval to orbicular; plants with odor of selenium .... *A. asclepiadoides*

— Leaves various, but if simple then linear to linear-oblanceolate; plants with or without odor of selenium 3

3(2). Leaves simple (rarely with leaflets on some leaves), the blades grass-like; plants acaulescent 4

— Leaves plurifoliolate, or rarely trifoliolate, or the uppermost only simple; if acaulescent never as above 5

4(3). Leaves not over 8 cm long; racemes with flowers usually fewer than 8, less than 3.5 cm long in fruit .... *A. spatulatus*

— Leaves usually more than 8 cm long; racemes with flowers usually more than 8, more than 4.5 cm long in fruit .... *A. chloodes*

5(3). Plants rush-like or sprawling, the terminal leaflet confluent with the rachis, and some of the upper leaves often simple (see also *A. duchensnensis*) 6

— Plants various, but seldom rush-like, the terminal leaflet jointed to the rachis and all leaves plurifoliolate (except in some *A. detritalis*, *A. aretioides* and *A. gilviflorus*) 10

6(5). Flowers 10 mm long or less; stems arising from a slender subterranean subrhizomatous caudex 7

— Flowers 15–20 mm long or more; stems arising from a superficial caudices 8

7(6). Pods bladder-inflated; pubescence of malpighian hairs; stems usually sprawling .... *A. ceramicus*

— Pods narrowly oblong, not inflated; pubescence of basifixed hairs; stems commonly erect .... *A. convallarius*

8(6). Flowers pink-purple; pods leathery-woody, laterally compressed; plants selenophytes of clays and silts, restricted to Uintah Co. .... *A. saurinus*

— Flowers ochroleucous to yellow; pods various, but not as above; plants selenophytes or not, from Uintah or Daggett cos. 9

9(8). Pods stipitate, pendulous; plants not with odor of selenium, usually 3.5 dm tall or more, known only from Uintah Co. .... *A. hamiltonii*

— Pods sessile or subsessile, ascending; plants seleniferous, less than 3.5 dm tall, known only from Daggett Co. .... *A. nelsonianus*

10(5). Plants annual, usually growing in sand; pods bladdery-inflated .... *A. geyeri*

— Plants perennial, of various soils; pods various 11

11(10). Pubescence of herbage consisting largely or entirely of malpighian hairs 12

— Pubescence of herbage consisting of basifixed hairs 18

12(11). Plants acaulescent or subacaulescent, the herbage grayish or whitish pubescent 13

— Plants caulescent, the herbage commonly green 16

13(12). Flowers ochroleucous, borne sessile among the leaves; leaves trifoliolate; plants of Summit Co. .... *A. gilviflorus*

— Flowers pink-purple or pale and suffused with purple, pedunculate; leaves with 5 or more leaflets on at least some leaves; plants of Daggett, Duchesne, and Uintah cos. 14

14(13). Leaves with leaflets 3, silvery strigose; flowers 6–8 mm long; plants local in Daggett Co. .... *A. aretoides*

— Leaves simple or with 3–17 leaflets, strigose but not silvery; flowers 13–20 mm long or more; plants more widely distributed 15

15(14). Plants strictly acaulescent; leaflets narrowly oblong, spinulose-tipped; pods linear-oblong .... *A. detritalis*

— Plants subacaulescent; leaflets obovate, rounded to obtuse apically; pods ellipsoid .... *A. chamaeleuce*

16(13). Plants selenophytes, usually of clay soils; flowers yellowish; pods unilocular .... *A. flavus*

— Plants not selenophytes, of various soils; flowers ochroleucous or pink-purple; pods bilocular 17

17(16). Flowers pink-purple, erect or steeply ascending at anthesis; stems from a caudex; plants known from Daggett Co. .... *A. adsurgens*

— Flowers ochroleucous, nodding at anthesis; stems from creeping rhizomes .... *A. canadensis*

18(12). Flowers small, the banner 12 mm long or less 19

— Flowers larger, the banner 12.5–25 mm long or more 30

19(18). Stipules all distinct, not even the lowermost connate 20

— Stipules connate-sheathing, at least at the lowest nodes 24

20(19). Plants dwarf, arising from a deeply seated caudex and elongate rhizome-like branches; flowers ochroleucous; pods bladdery-inflated, strigose, unilocular; plants of Green River Shale, Uintah Co. .... *A. lutosus*

— Plants differing from above, the caudex superficial; flowers pink-purple or ochroleucous; pods various, but if bladdery-inflated then bilocular or spreading-hairy 21

21(20). Flowers ochroleucous, suffused faintly with purple; pods bladdery-inflated, strigose to glabrous; plants of Wasatch and Summit cos. .... *A. lentiginosus*

— Flowers pink-purple or bicolored; pods not inflated or if so then spreading-hairy; plants of Summit, Duchesne, and Uintah cos. 22

22(21). Calyx more than half as long as the petals; pods sessile, straight, spreading; plants of moderate elevations, north slope of Uinta Mountains .... *A. eucosmus*

— Calyx less than half as long as the petals; pods stipitate or sessile, straight and pendulous or spreading and curved; plants of low elevations in the Uinta Basin 23

23(22). Leaflets linear to narrowly oblong; calyx teeth broadly triangular, 1 mm long or less; pods pendulous, straight, strigose .... *A. duchesnensis*

— Leaflets oblanceolate to obovate; calyx teeth narrowly subulate, more than 2 mm long; pods sessile, inflated, spreading, curved, long-pilose .... *A. pubentissimus*

24(19). Plants dwarf, less than 6 cm tall; caudex branches with a persistent thatch of marcescent stipules; flowers minute, 6.5 mm long or less; pods bladdery-inflated; known from Rich Co. .... *A. jejunus*

— Plants taller; caudex branches not as above; flowers commonly larger; pods not bladdery-inflated; distribution various 25

25(24). Stipules turning black on drying; flowers ochroleucous; pods short-stipitate, strongly laterally flattened .... *A. tenellus*

— Stipules not turning black on drying; flowers pink-purple or ochroleucous; pods various, but if as above then flowers pink-purple 26

26(25). Plants odoriferous selenophytes; flowers pink-purple or ochroleucous, the keel purple-tipped, numerous, nodding at anthesis; pods bisulcate ventrally .... *A. bisulcatus*

— Plants not smelling of selenium; flowers pink-purple or ochroleucous; pods not bisulcate ventrally 27

27(26). Flowers ochroleucous; pods long-stipitate more than 20 mm long at maturity, laterally compressed but not flattened; plants known from Wasatch Co. .... *A. australis*

— Flowers pink-purple or if stipitate then less than 15 mm long and flattened laterally 28

28(27). Pods and ovaries sessile or substipitate, the body flattened; plants known from Duchesne Co. .... *A. wingatanus*

— Pods and ovaries sessile or substipitate, the body various, but not strongly flattened; distribution various 29

29(28). Plants with sprawling stems, usually of pinyon-juniper and desert shrublands; pods terete, mostly 12 mm long or less; rare in Uintah Co. .... *A. flexuosus*

— Plants with upright stems, usually of aspen or spruce-fir woodlands; pods laterally compressed, usually 15 mm longer more .... *A. miser*

30(18). Plants acaulescent or subacaulescent; herbage grayish or silvery hairy 31

— Plants caulescent (subacaulescent in some *A. megacarpus*); herbage usually green 34

31(30). Leaves very densely hirsute-tomentose, with the longer hairs straight and spirally twisted; pods bilocular, densely woolly-hairy .... *A. mollissimus*

— Leaves variously pubescent, but if densely tomentose, the hairs all fine, sinuous, and cottony, none straight and spirally twisted 32

32(31). Pubescence of leaves various, but not of extremely fine entangled hairs; pods merely strigose .... *A. argophyllus*

— Pubescence of leaves softly villous-tomentose, consisting of fine, cottony, contorted or entangled hairs; pods both villous-tomentose and hirsute 33

33(32). Leaflets mostly obovate and obtuse; flowers bright pink-purple .... *A. utahensis*

— Leaflets either elliptic and acute or petals ochroleucous .... *A. purshii*

34(30). Plants subacaulescent; flowers pink-purple, 1–5 per raceme; pods bladdery-inflated, unilocular, commonly over 30 mm long .... *A. megacarpus*

— Plants differing in one or more ways from above 35

35(34). Plants odoriferous selenophytes, usually of clay soils at lower elevations; flowers nodding at anthesis 36

— Plants not with odor of selenium, usually of loamy soils at moderate elevations 37

36(35). Pods and ovaries strigose, at maturity ventrally bisulcate, mostly less than 15 mm long .... *A. bisulcatus*

— Pods and ovaries glabrous, at maturity trigonous, not bisulcate, mostly over 15 mm long .... *A. racemosus*

37(35). Stems arising from slender, rhizome-like caudex branches; flowers subsessile in head-like racemes, erect or ascending; pods erect, long-pilose, less than 12 mm long .... *A. agrestis*

— Stems arising from a caudex; flowers variously arranged, but if in head-like racemes then spreading; pods not erect, usually more than 15 mm long 38

38(37). Flowers in compact, head-like racemes; petals bicolored; pods oblong, dorsiventrally compressed .... *A. cibarius*

— Flowers in elongate racemes, or if somewhat shortened then petals pink-purple or the pods bladdery-inflated 39

39(38). Flowers ochroleucous; pods stipitate, pendulous .... *A. scopulorum*

— Flowers pink-purple; pods sessile, spreading .... *A. lentiginosus*

KEY V

Plants of Carbon, Emery, and Wayne Counties

1. Plants mat-forming or erect, with leaflets all spinulose-tipped and decurrent along the rachis .... *A. kentrophyta*

— Plants various, but not with both leaflets spinulose-tipped and decurrent along the rachis 2

2(1). Leaves simple, oval to orbicular; plants with odor of selenium .... *A. asclepiadoides*

— Leaves usually plurifoliolate, at least some (simple in *A. spatulatus*); plant with or without odor of selenium 3

3(2). Leaves simple; plants pulvinate caespitose; plants of Emery Co. .... *A. spatulatus*

— Leaves plurifoliolate, at least some; plants of various distribution 4

4(3). Plants rush-like or sprawling, the terminal leaflet confluent with the rachis, some of the uppermost leaves sometimes simple 5

— Plants various, but not or seldom rush-like, the terminal leaflet jointed to the rachis and all leaves plurifoliolate (rarely the lowermost simple) 14

5(4). Pubescence of herbage consisting largely or entirely of malpighian hairs 6

— Pubescence of herbage consisting of basifixed hairs 7

6(5). Flowers 10 mm long or less; stems arising singly from elongate, rhizome-like caudex branches; pods bladdery-inflated, stipitate; plants not with odor of selenium .... *A. ceramicus*

— Flowers 15 mm long or more; stems arising several together from a subterranean caudex; pods laterally compressed, sessile; plants with odor of selenium .... *A. woodruffii*

7(5). Flowers 10 mm long or less 8

— Flowers 11–25 mm long or more 10

8(7). Flower numerous; calyx densely pilose; pods short, spreading-ascending .... *A. moencoppensis*

— Flowers 12 or fewer; calyx merely strigose; pods narrowly oblong, declined to pendulous 9

9(8). Pods and ovaries stipitate; flowers bright pink-purple; plants of sandy washes; known only from Capitol Reef National Park .... *A. harrisonii*

— Pods and ovaries sessile; flowers dull purplish; plants of different distribution .... *A. convallarius*

10(7). Flowers ochroleucous; calyx brown; pods stipitate, pendulous; plants often over 50 cm tall .... *A. lonchocarpus*

— Flowers pink to pink-purple; calyx often cyaneus, not brown; pods various, usually sessile, or if stipitate then less than 40 cm tall 11

11(10). Plants tall selenophytes; flowers 20 mm long or more; plants of clay or silt in San Rafael Swell .... *A. rafaelensis*

— Plants not with odor of selenium; flowers 17 mm long or less; plants of various soils and distribution 12

12(11). Pods and ovaries sessile or nearly so; petals pale pink or tinged with purplish; plants of San Rafael Swell and southward .... *A. episcopus*

— Pods and ovaries stipitate, at maturity the stipe 3–6 mm long or more; petals mostly bright pink-purple; plants usually west or east of the San Rafael Swell proper 13

13(12). Caudex superficial; flowers spreading to declined at anthesis; plants mostly west of the San Rafael Swell proper .... *A. coltonii*

— Caudex subterranean; flowers ascending at anthesis; plants east of the San Rafael Swell proper .... *A. nidularius*

14(4). Plants definitely annual; flowers usually less than 8 mm long; pods bladdery-inflated and unilocular, or curved-oblong and bilocular 15

— Plants perennial, though sometimes flowering the first year, but the flowers then mostly over 8 mm long; pods various 16

15(14). Pods bladdery-inflated unilocular; stems and peduncles often 1 mm wide or more .... *A. geyeri*

— Pods curved-oblong, bilocular; stems and peduncles filiform, mostly less than 1 mm thick .... *A. nuttallianus*

16(14). Herbage pubescent largely or entirely with malpighian hairs 17

— Herbage pubescent with basifixed hairs 25

17(16). Plants caulescent; pods short, ascending; stipules connate, at least the lower-

most 18
— Plants acaulescent or subacaulescent, not smelling or selenium; pods various; stipules all distinct 19

18(17). Plants odoriferous selenophytes, of low elevations, pods unilocular .... *A. flavus*
— Plants not smelling of selenium, of moderate to high elevations; pods bilocular .... *A. adsurgens*

19(17). Wing tips deeply cleft apically; flowers usually bicolored or varicolored in populations; pods bilocular, oblong .... *A. calycosus*
— Wingtips entire; flowers various in color; pods unilocular, variously shaped 20

20(19). Leaflets (1) 3–5 (rarely more in *A. loanus*); plants strictly acaulescent, the caudex branches obscurred by a thatch of persistent leaf bases; pods spreading-hairy 21
— Leaflets mostly more than 5, at least on some leaves; plants various, but if strictly acaulescent the thatch poorly or not developed; pods strigose 22

21(20). Leaflets 1–3 on most leaves; flowers pink-purple; pods with hairs to 2 mm long; plants rather widespread in the region .... *A. musiniensis*
— Leaflets usually 5 on most leaves; flowers ochroleucous or tinged purplish; pods with hair 2–2.5 mm long; plants of western Wayne Co. .... *A. loanus*

22(20). Flowers ochroleucous, tinged purplish, 11–12.5 mm long; pods laterally compressed only near the apex; plants of western Emery and Wayne cos. .... *A. consobrinus*
— Flowers pink-purple or bicolored, mostly 15–25 mm long; pods laterally compressed throughout or dorsiventrally so 23

23(22). Pods laterally compressed, straight; persistent; flowers often pale or dull purplish; common in the vicinity of the San Rafael Swell .... *A. cymboides*
— Pods dorsiventrally compressed, usually curved, deciduous; flowers pink-purple or bicolored; common to uncommon in the region 24

24(23). Flower usually bicolored; walls of pod at least 1 mm thick, the endocarp and exocarp separated by a thick mesocarp; plants rare in the region .... *A. chamaeleuce*
— Flowers usually bright pink-purple; walls of pod less than 1 mm thick, becoming leathery when ripe; plants common .... *A. amphioxys*

25(16). Flowers small, the banner 12 mm long or less 26
— Flowers larger, the banner 12.5–15 mm long or more 39

26(25). Stipules all distinct, not even the lowermost connate 27
— Stipules connate-sheathing at least at the lowermost nodes 32

27(26). Flowers 5 mm long or less, 2–5, born on linear-filiform peduncles; plants sprawling, usually of volcanic gravels .... *A. brandegei*
— Flowers commonly 7 mm long or more, usually more than 5, borne on substantial peduncles; plants ascending to erect, never really sprawling, seldom, if ever, of volcanic soils 28

28(27). Plants subacaulescent, the stems shorter than the inflorescence; stipules prominent .... *A. desperatus*

— Plants caulescent, the stems longer than the inflorescence; stipules hardly prominent 29

29(28). Pods strongly mottled, bladdery-inflated, merely strigose; plants known from western Wayne Co. .... *A. serpens*

— Pods not or slightly mottled, inflated but hardly bladdery; villous with spreading hairs; plants mostly along the sandy eastern portion of the region 30

30(29). Racemes with 10 or more flowers; plants rare in the region .... *A. pubentissimus*

— Racemes with 10 or fewer flowers; plants rare to locally common 31

31(30). Pods 5–8 mm in diameter, curved-oblong; ovules 10–19; plants rare in the region .... *A. sabulonum*

— Pods 8–11 mm in diameter, ovoid-ellipsoid; ovules 20–28; plants locally common .... *A. pardalinus*

32(26). Stipules turning black on drying; flowers ochroleucous; pods short-stipitate, strongly laterally flattened; plants of the high plateau sections .... *A. tenellus*

— Stipules not turning black on drying; flowers various; pods various, but if as above then flowers pink-purple or plants of low elevations 33

33(32). Stems shorter than the inflorescences; flowers pink-purple, numerous; pods erect; sessile .... *A. moencoppensis*

— Stems longer than the inflorescences, or if shorter than the flowers 10 or fewer per raceme; pods seldom erect 34

34(33). Plants odoriferous selenophytes; flowers ochroleucous, numerous, nodding at anthesis; pods bisulcate ventrally .... *A. bisulcatus*

— Plants not smelling of selenium; flowers pink-purple or sometimes ochroleucous, ascending at anthesis; pods not bisulcate ventrally 35

35(34). Pods and ovaries stipitate, the body flattened or triquetrous 36

— Pods and ovaries sessile or subsessile, the body various but not strongly flattened 37

36(35). Pods not strongly compressed; wing petals bilobed; plants of high elevation in Emery Co. .... *A. australis*

— Pods strongly compressed; wing petals entire; plants of lower elevations in Carbon and Emery cos. .... *A. wingatanus*

37(35). Plants with elongate clambering stems, known from moist meadows in western Wayne Co. .... *A. bodinii*

— Plants with short to elongate, erect to sprawling stems of different distribution or habitat 38

38(37). Plants with sprawling stems, commonly of pinyon-juniper and desert shrublands; pods mostly 15 mm long or less; known from lower elevations Carbon and Emery cos. .... *A. flexuosus*

— Plants with upright stems, usually of aspen or spruce-fir woodlands; pods laterally compressed, usually 15 mm long or more .... *A. miser*

39(26). Plants acaulescent or subacaulescent; herbage grayish- or silvery-hairy 40

— Plants caulescent (subacaulescent in *A. megacarpus*); herbage usually green 43

40(39). Herbage merely strigose; flowers 13–15 mm long; stipules prominent; pods hirsute .... *A. barnebyi*

— Herbage tomentose to strigose; flowers 15–25 mm long; stipules not prominent; pods variously pubescent 41

41(40). Leaves very densely hirsute-tomentose, with the longer hairs straight and spirally twisted; pods bilocular, densely woolly-hairy .... *A. mollissimus*

— Leaves variously pubescent, but if densely tomentose, the hairs all fine, sinuous, and cottony, none straight and spirally twisted 42

42(41). Pubescence of leaves softly villous-tomentose, consisting of fine, cottony, contorted or entangled hairs; pods both villous-tomentose and hirsute .... *A. utahensis*

— Pubescence of leaves strigose, not of fine entangled hairs; pods strigose .... *A. argophyllus*

43(39). Plants subacaulescent; flowers pink-purple, 1–5 per raceme; pods bladdery-inflated, unilocular, often more than 30 mm long .... *A. megacarpus*

— Plants differing in one or more ways from above 44

44(43). Plants odoriferous selenophytes, usually of clay soils at low elevations; flowers ochroleucous and nodding or the calyx purple and flowers ascending 45

— Plants not smelling of selenium, of various soil types and elevations; flowers not with either of the combinations noted above 48

45(44). Flowers ochroleucous, nodding at anthesis; calyx whitish, cream-colored or greenish; pods woody 46

— Flowers pink-purple or bicolored, ascending at anthesis; calyx purple; pods leathery 47

46(45). Calyx and petals concolorous both whitish to cream-colored; pods cylindric, sessile, steeply ascending; plants of Carbon Co. .... *A. pattersonii*

— Calyx and petals discolorous, the calyx often greenish, the petals ochroleucous; pods spreading ascending or if steeply ascending, then stipitate .... *A. praelongus*

47(45). Pods horizontally spreading or declined, borne on ascending to reclinding peduncles; stems seldom more than 10 cm long; plants rare .... *A. eastwoodae*

— Pods erect or steeply ascending, born on erect peduncles; stems mostly much longer than 10 cm long; plants common .... *A. preussii*

48(44). Stems arising from slender, rhizome-like caudex branches; flowers subsessile in head-like racemes, erect or ascending; pods erect, long-pilose, less than 12 mm long .... *A. agrestis*

— Stems arising from a caudex; flowers variously arranged, but not or rarely head-like, spreading at anthesis; pods not as above 49

49(48). Flowers pink to pink-purple; pods sessile, bilocular .... *A. lentiginosus*

— Flowers ochroleucous; pods stipitate, uni- or bilocular 50

50(49). Stipules connate-sheathing at least some; pods bilocular, triquetrous, 3–5 mm wide .... *A. scopulorum*

— Stipules all distinct; pods unilocular, bladdery-inflated, 10–30 mm wide .... *A. oophorus*

KEY VI

Plants of Grand and San Juan Counties

1. Leaves simple, oval to orbicular; plants with odor of selenium .... *A. asclepiadoides*

— Leaves usually plurifoliolate (simple in *A. spatulatus*); plants with or without the odor of selenium 2

2(1). Leaves simple; plant pulvinate-caespitose, of Grand Co. .... *A. spatulatus*

— Leaves usually plurifoliolate; plant seldom as above, of various distribution 3

3(2). Plants rush-like or sprawling, the terminal leaflet of at least uppermost leaves confluent with the rachis, some of the uppermost leaves often simple 4

— Plants various but seldom rush-like, the terminal leaflet jointed to the rachis in all leaves, and all leaves plurifoliolate (rarely the lowermost simple) 8

4(3). Pubescence of herbage consisting of basifixed hairs; pods not bladdery-inflated .... *A. ceramicus*

— Pubescence of herbage consisting of basifixed hairs; pods not bladdery-inflated 5

5(4). Flowers 10 mm long or less 6

— Flowers 12 mm long or more 7

6(5). Stems shorter than the inflorescence; flowers numerous, pink-purple; pods spreading-ascending .... *A. moencoppensis*

— Stems longer than the inflorescences; flowers usually 15 or fewer, dull pink-purple; pods spreading-pendulous .... *A. convallarius*

7(5). Flowers ochroleucous; calyx brown; plants commonly 50 cm tall or more .... *A. lonchocarpus*

— Flowers pink-purple; calyx greenish or blackish; plants commonly less than 45 cm tall, local in White Canyon, San Juan Co. .... *A. nidularius*

8(3). Plants definitely annual (see also *A. sabulonum*); flowers usually less than 8 mm long; pods bladdery-inflated and unilocular, or curved-oblong and bilocular 9

— Plants perennial, though sometimes flowering the first year, but the flowers then mostly more than 8 mm long; pods various 10

9(8). Pods bladdery-inflated, unilocular; stems and peduncles often 1 mm thick or more .... *A. geyeri*

— Pods curved-oblong, bilocular or nearly so; stems and peduncles filiform, mostly less than 1 mm thick .... *A. nuttallianus*

10(8). Herbage pubescent largely or entirely with malpighian hairs 11

— Herbage pubescent with basifixed hairs 18

11(10). Plants caulescent selenophytes; pods erect, less than 12 mm long .... *A. flavus*

— Plants acaulescent or subacaulescent, not smelling of selenium; pods various 12

12(11). Stems diffuse and prostrate, sometimes matted; racemes 1- to 3-flowered .... *A. sesquiflorus*

— Stems various, but not as above; racemes commonly with more than 3 flowers 13

13(12). Plants strictly acaulescent; flowers less than 12 mm long, or leaflets 5 or fewer, or both 14

— Plants subacaulescent; flowers various; leaflets 5 or more on at least some leaves 15

14(13). Flowers 12 mm long or less; wing petals bilobed apically; pods bilocular .... *A. calycosus*

— Flowers 18–25 mm long; wing petals entire apically; pods unilocular .... *A. musiniensis*

15(13). Pods narrowly oblong to oblong-ellipsoid, straight, laterally compressed when ripe .... *A. cymboides*

— Pods obliquely ovoid to ellipsoid, mostly curved, if straight then dorsally compressed 16

16(15). Walls of pod at least 1 mm thick, the exocarp and endocarp separated by a thick mesocarp; petals mostly bicolored .... *A. chamaeleuce*

— Walls of pod much less than 1 mm thick, becoming leathery when ripe; petals pink-purple or bicolored 17

17(16). Pods persistent or tardily deciduous, mostly lance ovoid in outline; plants rare .... *A. missouriensis*

— Pods readily deciduous, ellipsoid in outline; plants common .... *A. amphioxys*

18(10). Flowers small, the banner 12 mm long or less 19

— Flowers larger, the banner 12.5–25 mm long or more 32

19(18). Stipules all distinct, not even the lowermost connate 20

— Stipules connate-sheathing at least at the lowermost nodes 25

20(19). Plants subacaulescent, the stems shorter than the inflorescences; stipules prominent 21

— Plants caulescent, the stems longer than the inflorescences; stipules inconspicuous 22

21(20). Pods spreading hairy, unilocular, dorsally compressed; plants widespread .... *A. desperatus*

— Pods strigose, bilocular, laterally compressed; plants of the Cedar Mesa Sandstone, San Juan Co. .... *A. monumentalis*

22(20). Stems arising from elongate rhizome-like caudex branches; pods narrowly oblong, pendulous; plants of Cutler formation, Comb Wash, San Juan Co. .... *A. cronquistii*

— Stems from a superficial caudex; pods ovoid to ellipsoid, mostly spreading; plants of various distribution 23

23(22). Petals whitish, with pink veins; pods ovoid-acuminate, strongly beaked, strigose; plants of Colorado River Canyon east from Moab .... *A. wetherillii*

— Petals pink-purple or less commonly ochroleucous; pods ellipsoid, to ovoid-ellipsoid, spreading hairy; plants of various distribution 24

24(23). Flowers 8.8–11.7 mm long, commonly more than 10 per raceme; pods mostly more than 8 mm in diameter; plants of the Tavaputs escarpment .... *A. pubentissimus*

— Flowers 5.8–8.2 mm long, commonly fewer than 10 per raceme; pods less than 8 mm in diameter; plants of San Juan Co. .... *A. sabulonum*

25(19). Stipules turning black on drying; flowers ochroleucous; pods short-stipitate; strongly laterally flattened .... *A. tenellus*

— Stipules not blackening on drying; flowers various; pods various; but if as above then flowers pink-purple 26

26(25). Stems shorter than the inflorescences; flowers pink-purple, numerous; pods erect, sessile .... *A. moencoppensis*

— Stems longer than the inflorescences of if shorter, then the flowers 10 or fewer per raceme; pods seldom erect 27

27(26). Plants odoriferous selenophytes; flowers ochroleucous, numerous, nodding at anthesis; pods bisulcate ventrally .... *A. bisulcatus*

— Plants not smelling of selenium; flowers pink-purple or sometimes ochroleucous, ascending at anthesis; pods not bisulcate ventrally 28

28(27). Pods sessile or subsessile, the body oblong 29

— Pods stipitate, or the body bladdery-inflated 30

29(28). Plants with sprawling or slender and erect stems; pods mostly less than 18 mm long, subterete; mostly of mountain brush and pinyon-juniper communities .... *A. flexuosus*

— Plants with erect stems; pods laterally compressed usually 19 mm long or more; mostly in aspen or spruce-fir communities .... *A. miser*

30(28). Flowers 8 mm long or less; pods strongly laterally flattened; plants mostly in pinyon-juniper woodlands .... *A. wingatanus*

— Flowers 8.5–11.5 mm long; pods various, but not as above; plants of various habitats 31

31(30). Herbage fresh green; racemes usually with fewer than 10 flowers; pods narrowly oblong, not inflated; plants of the Tavaputs Plateau, Grand Co. .... *A. alpinus*

— Herbage often cinereous; racemes with more than 10 flowers; pods bladdery-inflated; plants of lower elevations in San Juan Co. .... *A. fucatus*

32(18). Plants acaulescent or subacaulescent; herbage often grayish- or silvery-hairy 33

— Plants caulescent; herbage often green 36

33(32). Flowers 15 mm long or less; pods merely strigose, linear-oblong; plants of sandstone formations; San Juan Co. .... *A. cottamii*

— Flowers more than 15 mm long; pods variously pubescent, ovoid-ellipsoid to ellipsoid; plants of various habitats and distributions 34

34(33). Leaflets mostly 17 or more per leaf, densely hirsute-tomentose, with longer hairs straight and spirally twisted; pods bilocular, densely woolly-hairy .... *A. mollissimus*

— Leaflets mostly 15 or fewer, mostly strigose; pods unilocular 35

35(34). Leaflets mostly acute; pods brightly mottled; rocky ledges and talus of sandstone canyons and escarpments .... *A. zionis*

— Leaflets obtuse to acute; pods not mottled; plants mostly of humus in mountain brush and upwards .... *A. argophyllus*

36(32). Plants odoriferous selenophytes, usually of clay soils 37

— Plants not smelling of selenium, usually not of clay soils 43

37(36). Stipules connate into a bidentate sheath, at least at the lowermost nodes; flowers pink-purple, declined at anthesis; pods stipitate, pendulous, bisulcate .... *A. bisulcatus*

— Stipules all distinct, even at the lowermost nodes; flowers variously colored, but if declined at anthesis then ochroleucous; pods sessile or stipitate, ascending to spreading, not bisulcate 38

38(37). Calyx tube purple; petals pink-purple or bicolored; pods leathery-inflated 39

— Calyx tube green to whitish, not purplish; petal ochroleucous to whitish 40

39(38). Pods horizontally spreading or declined, borne on ascending to reclining peduncles; stems seldom more than 10 cm long; plants rare .... *A. eastwoodae*

— Pods erect or steeply ascending, borne on erect peduncles; stems mostly much longer than 10 cm; plants locally common .... *A. preussii*

40(38). Flowers declined at anthesis; pods ascending to erect, 9 mm in diameter or less, leathery-woody in texture 41

— Flowers spreading to ascending; pods spreading to declined, usually over 10 mm in diameter, leathery in texture 42

41(40). Calyx and petals concolorous, both whitish to cream-colored; pods cylindric, sessile, steeply ascending; plants not definitely known from the region but nearby in Colorado .... *A. pattersonii*

— Calyx and petals discolorous, the calyx greenish, the petals ochroleucous; pods spreading-ascending or if steeply ascending then stipitate; plants common in the region .... *A. praelongus*

42(40). Flowers 17–18 mm long, the petals whitish; calyx tube 5.5–6.3 mm long; plants of Paradox and Morrison formations; La Sal Mts. .... *A. isleyi*

— Flowers 28–31 mm long, the petals ochroleucous; calyx tube 11.5–14 mm long; plants of the Mancos Shale formation, north of the Colorado River .... *A. sabulosus*

43(36). Stems arising from slender, rhizome-like caudex branches; flowers subsessile in head-like racemes, erect or ascending; pods erect, long-pilose, less than 12 mm long .... *A. agrestis*

— Stems arising from a caudex; flowers variously arranged, but seldom head-like and ascending to spreading; pods more than 12 mm long, spreading to pendulous 44

44(43). Pods and ovaries sessile, spreading, either bladdery-inflated or curved oblong to straight, bilocular 45

— Pods and ovaries stipitate, descending to pendulous, not much inflated or curved, uni- or bilocular 46

45(44). Pods trigonous, the sides flattened, straight, 3–5 mm thick; plants rare or extinct in Glen Canyon .... *A. bryantii*

— Pods terete or dorsiventrally compressed to inflated, usually over 5 mm thick; plants common .... *A. lentiginosus*

46(44). Flowers ochroleucous; pods bilocular; plants fresh green .... *A. scopulorum*

— Flowers pink-purple; pods unilocular; plants more or less cinereus .... *A. coltonii*

KEY VII

Plants of Garfield and Kane Counties

1. Plants mat-forming or erect, with leaflets all spinulose-tipped and decurrent along the rachis .... *A. kentrophyta*

— Plants various, but not with leaflets both spinulose-tipped and decurrent along the rachis 2

2(1). Leaves simple, oval to orbicular; plants with odor of selenium .... *A. asclepiadoides*

— Leaves usually plurifoliolate, at least some; plants with or without the odor of selenium 3

3(2). Plants annuals (see also *A. subulonum*); flowers commonly less than 8 mm long; pods curved-oblong and bilocular or bladdery-inflated and ovoid 4

— Plants perennial, though sometimes flowering the first year, and then differing in one or more respects from above 6

4(3). Pods bladdery-inflated, unilocular; plants of eastern Garfield Co. .... *A. geyeri*

— Pods curved oblong, bilocular; plants of Kane and Garfield cos. 5

5(4). Keel tips rounded; leaflets all truncate-retuse on all leaves; pods deciduous, dehiscing at both ends after falling .... *A. emoryanus*

— Keel tips pointed; leaflets not truncate-retuse on all leaves; pods persistent, dehiscent at tip only .... *A. nuttallianus*

6(3). Plants with terminal leaflets confluent with the rachis, the uppermost leaves sometimes simple 7

— Plants with terminal leaflets jointed to the rachis, the leaves all plurifoliolate (or the lowermost simple) 16

7(6). Pubescence of herbage consisting largely or entirely of malpighian hairs 8

— Pubescence of herbage consisting of basifixed hairs 9

8(7). Flowers 10 mm long or less; stems arising singly from elongate, rhizome-like caudex branches; pods bladdery-inflated, stipitate .... *A. ceramicus*

— Flowers 15 mm long or more; stem arising several together from a subterranean caudex; pods laterally compressed sessile .... *A. woodruffii*

9(7). Flowers ochroleucous, or whitish tinged with pink, 15 mm long or more 10

— Flowers pink-purple bicolored, or pale, 12 mm long or less 11

10(9). Inflorescences usually shorter than the subtending leaves; calyx not brown; pods sessile, curved; plants clump-forming not slender and tall, of western Kane Co. .... *A. tetrapetrus*

— Inflorescence much longer than the subtending leaves; calyx brown; pods long-stipitate, pendulous, straight; plants tall and slender, widespread .... *A. lonchocarpus*

11(9). Stems shorter than the inflorescences; flowers numerous; calyx densely pilose; pods short, spreading-ascending .... *A. moencoppensis*

— Stems shorter or longer than the inflorescences; flowers few to numerous; calyx merely strigose; pods various but not as above 12

12(11). Flowers dull pink-purple, usually 10 mm long or less; pods narrowly oblong, sessile, the body 4 mm wide or less .... *A. convallarius*

— Flowers pale to bright pink-purple, usually over 10 mm long, or pods more than 5 mm wide 13

13(12). Pods and ovaries sessile; petals pale; plants west and south of the Henry Mountains 14

— Pods and ovaries stipitate, at maturity the stipe 3–6 mm long or more; plants west or east of those mountains 15

14(13). Calyx short-cylindric, the tube longer than broad, suffused purplish or very pale, white-strigose; ovules 16–26 .... *A. episcopus*

— Calyx campanulate, the tube about as long as broad, not purplish, black-strigose; ovules 8–14 .... *A. lancearius*

15(13). Caudex superficial; flowers spreading or declined at anthesis; plants west of the Henry Mountains .... *A. coltonii*

— Cadex subterranean; flowers ascending at anthesis; plants east of the Henry Mountains .... *A. nidularius*

16(6). Herbage pubescent, largely or entirely, with malpighian hairs 17

— Herbage pubescent with basifixed hairs 25

17(16). Plants caulescent; pods short, ascending 18

— Plants acaulescent or subacaulescent; pods various 20

18(17). Plants erect or descending; flowers mostly more than 12 m long; odoriferous selenophytes .... *A. flavus*

— Plants prostrate-spreading; flowers less than 12 mm long; not smelling of selenium 19

19(18). Racemes 1- to 3-flowered; flowers pink-purple; leaflets 7–11 plants of sandstone escarpments and ledges, mostly at lower elevations .... *A. sesquiflorus*

— Racemes 7- to many-flowered; flowers dull purplish; leaflets 11–17; plants mostly of higher plateaus .... *A. humistratus*

20(17). Plants subacaulescent, with one or more internodes usually apparent; caudex branches only rarely with persistent leaf bases 21

— Plants strictly acaulescent, the caudex branches usually with a persistent thatch of leaf bases 22

21(20). Flowers usually bicolored; walls of pod at least 1 mm thick, the exocarp and endocarp separated by a thick mesocarp; plants rare in the region .... *A. chamaeleuce*

— Flowers usually bright pink-purple; walls of pod less than 1 mm thick, becoming leathery when ripe; plants common .... *A. amphioxys*

22(20). Flowers mostly less than 12.5 mm long; pods less than 17 mm long 23

— Flowers more than 15 mm long; pods more than 20 mm long 24

23(22). Flowers pink to pink-purple, or bicolored, or ochroleucous, the wing petals emarginate apically; pods linear-oblong, bilocular .... *A. calycosus*

— Flowers ochroleucous, the wing petals entire apically; pods ovoid-ellipsoid, unilocular .... *A. consobrinus*

24(22). Leaflets 1–3 on most leaves; flowers pink-purple; pods with hairs to 2 mm long; plants mostly east of the high plateaus .... *A. musiniensis*

— Leaflets 5 on most leaves; flowers ochroleucous or tinged purplish; pods with hairs 2–2.5 mm long; plants of western Garfield Co. .... *A. loanus*

25(16). Flowers small, the banner 12 mm long or less 26

— Flowers larger, the banner 12.5–25 mm long or more 40

26(25). Flowers 6 mm long or less; pods unilocular, borne on slender peduncles, resupinate; stems sprawling; plants usually of volcanic gravels .... *A. brandegei*

— Flowers over 6 mm long, and the plants differing in other ways, usually not of volcanic gravels (or seldom so) 27

27(26). Plants with stipules all distinct, not even the lowermost connate 28

— Plants with stipules connate-sheathing, at least the lowermost 33

28(27). Plants subacaulescent; stipules prominent; stems shorter than the inflorescences 29

— Plants caulescent; stipules not conspicuous; stems longer than the inflorescences 30

29(28). Pods spreading-hairy unilocular, dorsally compressed; plants widespread along canyons of the Colorado .... *A. desperatus*

— Pods strigose, bilocular, laterally compressed; plants of Cedar Mesa Sandstone, eastern Garfield Co. .... *A. monumentalis*

30(28). Pods bladdery-inflated, diaphanous, strigose to glabrous; plants of moderate to high elevations in western Kane and western to eastern Garfield cos. 31

— Pods only moderately inflated, opaque, spreading-hairy; plants of low elevations in eastern portions of Kane and Garfield cos. 32

31(30). Flowers ochroleucous; pods sessile, glabrous, or nearly so, usually not mottled .... *A. wardii*

— Flowers pink-purple; pods strigose, short-stipitate, strongly mottled ....
.... *A. serpens*

32(30). Pods 5–8 mm in diameter, curved-oblong; ovules 10–19; plants of eastern Kane Co. .... *A. sabulonum*

— Pods 8–11 mm in diameter, ovoid-ellipsoid; ovules 20–28; plants of eastern

Garfield Co. .... *A. pardalinus*

33(27). Plants subacaulescent, the stems shorter than inflorescences; pods bladdery-inflated; growing in sand, on beaches, or volcanic gravels 34

— Plants caulescent, the stems shorter or longer than the inflorescences, when shorter, the pods not inflated; growing in various soil types and habitats 36

34(33). Flowers ochroleucous; plants of beaches in western Kane Co. .... *A. limnocharis*

— Flowers pink-purple to whitish; plants of sandy sites at low elevations or of volcanic gravels at high elevations 35

35(34). Flowers 8–9 mm long, the banner not strongly veined; plants of volcanic gravels at high elevations in western Garfield Co. .... *A. perianus*

— Flowers 10–12 mm long, the banner strongly veined; plants of sandy sites at low elevations in Kane Co. .... *A. striatiflorus*

36(34). Stipules turning black on drying; flowers ochroleucous; pods short-stipitate, strongly laterally flattened .... *A. tenellus*

— Stipules not blackening on drying; flowers various; pods various, but not as above 37

37(36). Stems shorter than the inflorescences; flowers pink-purple; numerous, calyx densely villous; pods spreading-ascending, sessile .... *A. moencoppensis*

— Stems longer than the inflorescences, or if shorter, the flowers 10 or fewer, or the pods not spreading-ascending; calyx merely strigose 38

38(37). Pods oblong, not inflated; plants of aspen and spruce-fir communities at higher elevations .... *A. miser*

— Pods inflated to bladdery-inflated; plants commonly of ponderosa pine, pinyon-juniper, or desert shrub communities at moderate to lower elevations 39

39(38). Calyces and stems silvery-caulescent, the hairs appressed; pod bladdery-inflated, more than 12 mm in diameter; ovules 21–32; plants of sandy sites at low elevations in eastern Garfield Co. .... *A. fucatus*

— Calyces and stems not silvery-caulescent, the hairs spreading; pods moderately inflated less than 13 mm in diameter; ovules 10–20; plants of moderate elevations in Kane and Garfield cos. .... *A. subcinereus*

40(25). Plants acaulescent or subacaulescent; herbage often grayish or silvery-hairy 41

— Plants caulescent; herbage often green 48

41(40). Flowers 15 mm long or less, pink-purple; pods curved, 10–12 mm long, densely spreading-hairy; plants rare and local, Garfield Co. .... *A. barnebyi*

— Flowers more than 15 mm long; pods curved or straight, more than 12 mm long, variously hairy; plants of various distribution 42

42(41). Plants strictly acaulescent; caudex branches with a thatch of persistent stipules 43

— Plants subacaulescent; caudex branches with thatch poorly developed or lacking 45

43(42). Flowers ochroleucous, 15–23 mm long; pods lance-ovoid, strigose; plants known only from the Henry Mountains .... *A. henrimontanensis*

— Flowers ochroleucous or pink-purple, 18–25 mm long or more; pods spreading-hairy or villous; plants of various distribution but not as above 44

44(43). Flowers ochroleucous, sometimes suffused with purple; valves of pod scarcely obscured by the curly hairs .... *A. eurekensis*

— Flowers pink-purple; valves of pod obscured by contorted under hairs .... *A. newberryi*

45(42). Leaflets mostly 17 or more per leaf, densely hirsute-tomentose, with longer straight hairs spirally twisted; pod bilocular, densely woolly hairy .... *A. mollissimus*

— Leaflets mostly fewer than 17 per leaf, variously hairy, but not with longer straight hairs spirally twisted; pod unilocular, variously hairy 46

46(45). Leaflets oval to obovate, rounded apically; pods woolly hairy .... *A. utahensis*

— Leaflets oblanceolate to elliptic, obtuse to acute apically; pods merely strigose 47

47(46). Leaflets mostly acute; pods brightly mottled; plants of rocky ledges and talus of sandstone canyons and escarpments, mostly at lower elevations .... *A. zionis*

— Leaflets obtuse to acute; pods not mottled; plants of loamy soils in mountain brush and upwards .... *A. argophyllus*

48(40). Plants odoriferous selenophytes, usually of clay soils 49

— Plants not smelling of selenium, usually not of clay soils 52

49(48). Calyx tube purple; petals pink-purple or bicolored; flowers erect-ascending at anthesis; pods leathery-inflated, ascending .... *A. preussii*

— Calyx tube greenish or whitish, not purplish; petals ochroleucous, or keel-tip purple, descending at anthesis; pods various 50

50(49). Stipules connate into a bidentate sheath, at least at the lowermost nodes; pods stipitate, pendulous, bisulcate .... *A. bisulcatus*

— Stipules all distinct, even at the lowermost nodes; pods sessile or shortly stipitate, ascending to spreading, not bisulcate 51

51(50). Calyx and petals concolorous, both whitish to cream-colored; pods cylindric, sessile, steeply ascending; plants rare in Henry Mountains .... *A. pattersonii*

— Calyx and petals discolorous, the calyx greenish, the petals ochroleucous; pods broadly ellipsoid, sessile or shortly stipitate, spreading-ascending; plants common .... *A. praelongus*

52(48). Plants subacaulescent; flowers pink-purple, 1–5 raceme; pods bladdery-inflated, unilocular, often more than 30 mm long .... *A. megacarpus*

— Plants differing in one or more respects from above 53

53(52). Stems arising from slender, rhizome-like caudex branches; flowers subsessile in head-like racemes, erect or ascending; pods erect, long-pilose, less than 12 mm long .... *A. agrestis*

— Stems arising from a superficial or subterranean caudex; flowers variously arranged, but seldom head-like and ascending to spreading; pods more than 17 mm long, spreading to pendulous 54

54(53). Stipules connate-sheathing, at least at the lowermost nodes; caudex subterranean 55

— Stipules all distinct, even at the lowermost nodes; caudex superficial to subterranean 56

55(54). Pods and ovaries long-stipitate; plants known from clay soils of the Chinle formation .... *A. ampullarius*

— Pods and ovaries sessile or subsessile; plants known from sandy aluvium .... *A. hallii*

56(54). Pods and ovaries stipitate, the stipe at maturity subequal to or surpassing the calyx 57

— Pods and ovaries sessile or nearly so 58

57(56). Stems decumbent to ascending; pods bladdery-inflated, unilocular, the body mostly more than 25 mm long; flowers ochroleucous; plants commonly of higher middle elevations .... *A. oophorus*

— Stems erect; pods not or only somewhat inflated, bilocular, the body usually less than 20 mm long; flowers ochroleucous or pink-purple; plants of lower elevations .... *A. eremiticus*

58(56). Flowers borne in subcapitate racemes; pods curved-oblong, dorsiventrally compressed, unilocular .... *A. cibarius*

— Flowers usually in elongate racemes; pods ovoid to curved-oblong, bilocular, compression variable 59

59(58). Plants from a subterranean caudex, usually less than 25 mm tall; pods curved-oblong, laterally or trigonously compressed; known from the Kaiparowits and Circle Cliffs regions, at moderate elevations .... *A. malacoides*

— Plants from a superficial caudex, often more than 25 cm tall; pods curved-oblong and dorsiventrally compressed, or bladdery-inflated and ovoid; widespread .... *A. lentiginosus*

Astragalus adanus **A. Nels.** Boise Milkvetch. Perennial, caulescent, 20–45 cm tall, from a branching caudex; pubescence basifixed; stems erect or ascending; stipules 4–9 mm long, all distinct; leaves 7–13 (16) cm long; leaflets 13–27, ovate to oblong, lance-oblong, or elliptic, 6–26 mm long, retuse to obtuse, glabrous above, strigose below; peduncles (4) 10–18 cm long; racemes 4- to 27-flowered, the flowers ascending to spreading at anthesis, the axis 2–3 cm long in fruit; bracts lanceolate, 1.5–3.5 mm long; pedicels 1–5 mm long; bracteoles usually 2; calyx 6.9–10.3 mm long, often black-pilose, the tube 5.2–8 mm long, short-cylindric, the teeth 1.6–2.8 long, triangular-subulate; flowers ochroleucous, 15.5–22 mm long; pods erect, sessile, oblong-ovoid, 3–18 mm long, 5–6 mm thick; ovules 14–18. Known in Utah from a single collection at the base of Mt. Nebo, Juab Co. (Mt. Nebo R.S., R. K. Gierisch 288, UTC); Idaho; 1 (0).

Astragalus adsurgens **Pallas.** Standing Milkvetch. [*A. striatus* Nutt. ex torr. & Gray; *A. nitidus* Douglas ex Hook.; *A. nitidus* var. *robustior* (Hook.) M. E. Jones.]. Perennial, caulescent, 15–45 cm tall, from a branching caudex; pubescence malpighian; stems decumbent-ascending to erect; stipules 6–10 mm long, at least the lowermost connate-sheathing; leaves 6–12 cm long; leaflets 15–23, 13–28 mm long, 3–9 mm wide, oblong to elliptic, acute or obtuse; peduncles 6–16 cm long; racemes 16- to 50-flowered, the flowers ascending at anthesis, the axis 1.5–13 cm long in fruit; bracts 2–5 mm long; pedicels to 0.8 mm long; bracteoles 0; calyx 5.8–10.5 mm long, the tube 4.4–7 mm long, short-cylindric, strigulose, the teeth 1.4–4.2 mm long, subulate; flowers 13–16 mm long, pink-purple; pods erect, sessile, ovoid-oblong, 7–12 mm long, 2.3–3.8

mm thick bilocular; ovules 9–16. Juniper-sagebrush community at 2000 m in Daggett Co. and 3175 m in Emery and Sanpete cos.; Alaska east to Manitoba and south to Washington, Idaho, Colorado, Nebraska, and Iowa; Eurasia. Our material belongs to ssp. ***robustior*** **(Hook.) Welsh** (*A. adsurgens* var. *robustior* Hook.); 3 (i).

Astragalus agrestis **Douglas ex G. Don.** Field Milkvetch. [*A. dasyglottis* Fisch, ex DC, not Pallas; *A. goniatus* Nutt. ex Torr. & Gray; *A. hypoglottis polyspermus* Torr. & Gray; *A. agrestis* var. *polyspermus* (Torr. & Gray) M. E. Jones.] Perennial, caulescent, 9–43 cm tall, from a subterranean caudex and long rhizome-like caudex branches; pubescence basifixed; stems erect to decumbent-clambering; stipules 4–11 mm long, at least the lowermost connate-sheathing; leaves 2–10 cm long; leaflets 13–23, 4–18 mm long, 2–5 mm wide, narrowly elliptic to lance-oblong, obtuse to retuse or acute, strigulose above and below; peduncles 1.5–15 cm long; racemes subcapitate, 5- to 15-flowered, the flowers ascending-erect at anthesis, the axis 0.5–2.5 mm long in fruit; bracts 3–7 mm long; pedicels 0.5–1.5 mm long; bracteoles 0; calyx 7–12.5 mm long, the tube 5–7.8 mm long, cyclindric, villous, the teeth 2.5–5.5 mm long, linear; flowers 17–24 mm long, pink-purple, ochroleucous, or almost white; pods short-stipitate, the stipe 0.3–1 mm long, the body 7–10 mm long, 2.8–4.5 mm thick, unilocular, oblong-ellipsoid, silky-villous; ovules 14–26. Meadows and openings in sagebrush and aspen at 1850 to 3050 m in Box Elder, Cache, Carbon, Daggett, Duchesne, Emery, Garfield, Juab, Kane, San Juan, Sanpete, Sevier, Summit, Tooele, Uintah, Utah (US) Wasatch, and Wayne cos.; Yukon east to Ontario, and south to California, Nevada, New Mexico, Nebraska, and Iowa; 54 (xvi).

Astragalus alpinus **L.** Alpine Milkvetch. Perennial, caulescent, 2–30 cm tall, from a subterranean caudex and rhizomatous caudex branches; pubescence basifixed; stems decumbent to ascending; stipules 1.5–8 mm long, at least the lowermost connate-sheathing; leaves 3–15 cm long; leaflets 15–26, 6–20 mm long, 2–10 mm wide, ovate to elliptic or oblong, retuse to rounded, strigulose above and below; peduncles 3–15 cm long; racemes 5- to 17-flowered, the flowers erect to declined at anthesis, the axis 0.5–5 cm long in fruit; bracts 1–2.5 mm long; pedicels 0.5–2.3 mm long; bracteoles 0; calyx 3.2–6.3 mm long, the tube 2–3.5 mm long, campanulate, strigulose, the teeth 1–3.2 mm long; flowers 9–12 mm long, pink-purple; pods pendulous, stipitate, the stipe 2–5 mm long, the body oblong-lanceolate in outline, 10–17 mm long, 1.5–4 mm thick, strigulose, semibilocular; ovules 5–11. Aspen and coniferous woods at 2430 to 2730 m in Grand (on Tavaputs Plateau) and Salt Lake (at Brighton) cos., and to be sought elsewhere; Alaska to Nova Scotia and south to Oregon, Nevada, New Mexico, Wisconsin and Vermont; Eurasia; 2 (0).

Astragalus amphioxys **A. Gray.** Crescent Milkvetch. Perennial (rarely flowering the first year), subacaulescent to shortly caulescent, 2–20 cm tall, from a weak caudex; pubescence malpighian; stems lacking or up to 20 cm long, the internodes often concealed by stipules; stipules 2–13 mm long, all distinct or the lowermost sometimes connate-sheathing; leaves 2–13 mm long; leaflets (1) 5–21, 3–20 mm long, 1–9 mm wide, elliptic to obovate or oblanceolate, obtuse to acute, strigose on both sides; peduncles 2–15 (20) cm long; racemes 2- to 13-flowered, the flowers ascending at anthesis, the axis 1–6.5 cm long in fruit; bracts 2.5–8 mm long; pedicels 0.6–2.5 mm long; bracteoles 0–2; calyx 6.3–14.2 mm long, the tube 5.2 mm long cylindric, strigose, usually purplish; the teeth 1.1–4.5 mm long, subulate; flowers 16.5–31 mm long, pink-purple, rarely white; pods ascending, sessile, 1.5–5 cm long, 5–12 mm thick, usually curved, mostly dorsiventrally compressed, unilocular, strigose; ovules 42–70. Two rather feeble and sympatric varieties are present.

1. Banner twice as long as the calyx or less; keel 14.3–19 mm long .... *A. amphioxys* var. *amphioxys*

— Banner more than twice as long as the calyx; keel 17–25 mm long .... *A. amphioxys* var. *vespertinus*

Var. *amphioxys.* [*A. shortianus* var. (?) *minor* A. Gray; *Xylophacos amphioxys* (A. Gray) Rydb. *X. aragalloides* Rydb.; *X. melanocalyx* Rydb.; *A. amphioxys* var. *melanocalyx* (Rydb.) Tidestr.; *A. marcus-jonesii* Munz].— Desert shrub, pinyon-juniper, and less commonly in mountain brush communities at 670 to 1830 m in Emery, Garfield, Grand, Iron, Kane, San Juan, Washington, and Wayne cos.; Nevada, Arizona, and New Mexico; 133 (xxxiii).

Var. *vespertinus* (Sheldon) M. E. Jones [*A. vespertinus* Sheldon]. Desert shrub, pinyon-juniper, and rarely in mountain brush communities at 670 to 1530 m in Emery, Garfield, Grand, Kane, San Juan, Washington, and Wayne cos.; Colorado, Arizona, Nevada, and New Mexico; 104 (xl).

Astragalus ampullarius **S. Wats.** Gumbo Milkvetch. [*Tragacantha ampullaria* (S. Wats.) Kuntze; *Phaca ampullaria* (S. Wats.) Rydb.]. Perennial, shortly caulescent, 2–28 cm tall, from a deep subterranean caudex; pubescence basifixed; stems prostrate-ascending, radiating; stipules 2–6 mm long, at least the lowermost connate-sheathing; leaves 3–14 cm long; leaflets 7–15 (19), 4–15 mm long, 2–12 mm wide, obovate, rounded to emarginate, strigose on both sides or glabrous above; peduncles 0.5–9.5 cm long; racemes 5- to 30-flowered, the flowers ascending at anthesis, the axis 1.2–13 cm long in fruit; bracts 1.5–3 mm long; pedicels 1–3 mm long; bracteoles 2; calyx 4.8–7.5 mm long, the tube 4.2–6 mm long short-cylindric, black strigose, the teeth 0.5–1.5 mm long, broadly triangular; flowers 13.5–22 mm long, pink-purple with white wing-tips, or ochroleucous; pods ascending-erect, stipitate, the stipe 9–19 mm long, the body ovoid to subglobose, inflated, 12–20 mm long, 8–11 mm thick, subunilocular, glabrous or nearly so; ovules ca. 12. Clay soils of the Chinle and Tropic (?) Shale formations at 970 to 1650 m in Kane (west of the Cockscomb) and Washington cos.; Mohave and Coconino cos., Arizona. The gumbo milkvetch is certainly one of the most unusual of the vast array of species in Utah. Its propensity for the variegated shales of the Chinle Formation near Kanab (the type locality) has long been known. The hypogeous caudex and short, prostrate-ascending stems, which persist in rosette form with marcescent stems and pods of previous years circular-reclining, bleached and skeleton-like, are quite unlike any of the taxa within the region. Phases of *A. eremiticus*, q.v., with inflated ovoid-oblong pods resemble *A. ampullarius*, but the caudex is superficial, the stipules are all distinct, and the stems commonly are erect; 11 (iii).

Astragalus argophyllus **Nutt. ex Torr. & Gray.** Silver-leaved Milkvetch. Perennial, acaulescent to subacaulescent, 1.5–12 cm tall, arising from a superficial caudex; pubescence basifixed; stems obsolete or to 10 cm long, prostrate; stipules 2–10 mm long, all distinct; leaves 1.5–12 cm long; leaflets 7–21, 2–12 mm long, 1–6 mm wide, elliptic, oblanceolate or obovate, acute to obtuse, pilose above and below; peduncles to 9 cm long; racemes 1- to 6-flowered, the flowers ascending at anthesis, the axis little elongating in fruit; bracts 1.8–6.5 mm long; pedicels 1.2–3.8 mm long, bracteoles 0–2; calyx 9–16.8 mm long, the tube 6.5–11.8 mm long, cylindric, pilose with mixed black and white hairs, the teeth 1.5–6 mm long, linear; flowers 15–25 mm long, pink-purple; pods ascending, sessile, 1.5–3.7 mm long, 5–13 mm thick, ovoid-acuminate, unilocular, strigose or rarely villous, the valves not obscured; ovules 25–43. Three rather distinctive varieties are present.

1. Flowers 15–17.5 mm long, the keel 12–15.2 mm long; pods curved-ellipsoid, densely silky strigose, 3–4 times longer than broad .... *A. argophyllus* var. *panguicensis*

– Flowers 18–25 mm long, the keel 15.9–21 mm long; pods various, variably pubescent, mostly 2–3 times longer than broad 2

2(1). Petals bright pink-purple, the flowers 22–25 mm long; plants of grasslands, streambanks, and lake shores .... *A. argophyllus* var. *argophyllus*

— Petals dull pink-purple or pale, the flowers 18–22.5 mm long; plants of sagebrush and mountain brush communities .... *A. argophyllus* var. *martinii*

Var. *argophyllus*. [*Xylophacos argophyllus* (Nutt.) Rydb.; *A. uintensis* M. E. Jones, in part; *X. uintensis* (M. E. Jones) Rydb.]. Meadows, stream banks, and lake shores at 1400 to 1970 m in Box Elder, Cache, Carbon, Salt Lake, San Juan, Sanpete, Summit, Utah, Wasatch, and Weber cos.; Nevada, Idaho, and Wyoming; 22 (ii).

Var. *martinii* M. E. Jones. [*A. argophyllus* var. *cnicensis* M. E. Jones; *A. agrophyllus* var. *pephragmenoides* Barneby]. Sagebrush, mountain brush, aspen, and spruce-fir communities at 1700 to 2600 m in Beaver, Carbon, Duchesne, Emery, Grand, Iron, Juab, Millard, Piute, Salt Lake, Sanpete, Sevier, Summit, Tooele, Uintah, Utah, Wasatch, and Wayne cos.; Idaho, Wyoming, and Colorado; 54 (xi).

Var. *panguicensis* (M. E. Jones). M. E. Jones; [*A. chamaeleuce* var. *panguicensis* M. E. Jones; *A. panguicensis* (M. E. Jones) M. E. Jones; *Batidophaca sabinarum* Rydb.; *A. sabinarum* (Rydb.) Barneby]. Ponderosa pine, aspen-douglas fir-limber pine, white fir, sagebrush, and pinyon-juniper communities at 2130 to 2900 m in Garfield, Iron, Kane and Washington cos.; Arizona; 50 (ix).

Astragalus aretioides (M. E. Jones) Barneby. Cushion orophaca. [*A. sericoleucus* var. *aretioides* M. E. Jones]. Perennial, pulvinate caespitose, from a branching caudex; pubescence malpighian; stems almost entirely concealed by stipules; stipules 3.5–7 mm long, connate-sheathing, hyaline, glabrous dorsally or nearly so; leaves 0.6–2 cm long, palmately trifoliolate, the leaflets 3–7.5 mm long, 1.2–1.8 mm wide, spatulate to elliptic, acute, silvery-strigose on both sides; peduncles 7–15 mm long; racemes 2- or 3-flowered, the flowers ascending, the axis very short; bracts 2–3 mm long; pedicels 1–1.5 mm long; bracteoles 0; calyx 3.3–4.2 mm long, the tube 2.1–2.3 mm long, campanulate, densely long-strigose, the teeth 1.2–2 mm long; flowers 6–8 mm long, pink-purple (rarely white); pods ascending, sessile, 4–5 mm long, 1.2–2 mm thick, densely hairy, unilocular. Volcanic ash "barrens" at 1769 m in Daggett Co.; Montana and Wyoming; 2 (0).

Astragalus asclepiadoides **M. E. Jones.** Milkweed Milkvetch. [*Jonesiella asclepiadoides* (M. E. Jones) Rydb.]. Perennial, caulescent, 7–62 cm tall, arising from a usually superficial caudex; pubescence basifixed; stems glabrous, erect; stipules 2–15 mm long, all distinct; leaves simple, 1.5–6.5 cm long, 1–5.5 cm wide, ovate, orbilcular, or cordate, obtuse to rounded or retuse, glabrous; peduncles 0.5–4.5 cm long; racemes 2- to 12-flowered, the flowers ascending, the axis 0.4–2.5 cm long in fruit; bracts 1–5 mm long; pedicels 1–5 mm long; bracteoles usually 2; calyx 10–17 mm long, the tube 8.3–13 mm long, cylindric, strigose with black hairs, the teeth 1.5–3.8 mm long, linear to subulate; flowers 17–27 mm long, suffused purple or almost ochroleucous; pods erect-ascending, stipitate, the stipe 10–21 mm long, the body ovoid or ovoid-ellipsoid, inflated, 25–35 mm long, 11–16 mm thick, unilocular, glabrous; ovules ca 40. Saline desert shrub vegetative types on Mancos Shale, Tropic Shale, Carmel, Moenkopi, Arapien, and Duchesne River formations at 1250 to 1900 m in Carbon, Duchesne, Emery, Garfield, Grand (type from Cisco), Sanpete, Sevier, Uintah, and Wayne cos.; Colorado. This singular selenophyte was first collected by M. E. Jones (1923) ". . . on sand-bars along the Price River. . . ." in September of 1888, but the locality is apparently unique, for it is commonly distributed on the clay soils of the Mancos Shale in that vicinity; 42 (xvi).

Astragalus australis **Fischer.** Subarctic Milkvetch. (*A. aboriginum* Richards., for a complete list of synonyms, see Barneby 1964.) Perennial, caulescent, 6–20 cm tall, from a superficial caudex; pubescence basifixed; stems pubescent, erect; stipules 2–7 cm long, at least the lowermost connate-sheathing; leaves 2–7 cm long, sessile; leaflets 7–15, 3–22 mm long, 1–7 mm wide, elliptic, acute, villous to glabrate on both sides; peduncles 2–8.5 cm long; racemes 2- to 30-flowered, compact and ascending at anthesis, the axis 1–10 cm long in fruit; bracts 1.2–5 mm long; pedicels 0.8–3.5 mm long; bracteoles 0; calyx 3.7–6.4 mm long, the tube 2.1–3.9 mm long, campanulate, villous, the teeth 1–3 mm long, subulate; flowers 7.5–12.6 mm long, ochroleucous or suffused with pink, the wing petals bilobed apically; pods pendulous, stipitate, the stipe 2.5–6 mm long, the body obliquely and narrowly elliptic in outline, 13–27 mm long, 3–6 mm wide, semibilocular, glabrous; ovules 8–16. The subarctic milkvetch is one of the poorly known species within Utah. It is recorded from only three collections. The plants grow on calcareous ridges with grasses and shrubs at elevations of from 1750 to 3050 m in Piute (Marysvale, 10000 ft., Jones in 1899, POM), Emery, and Wasatch cos.; Alaska east to Gaspé, and south to Oregon, Nevada, Colorado, and South Dakota; 3 (ii).

***Astragalus barnebyi* Welsh in Welsh, Atwood, & Reveal.** Barneby Milkvetch. [*A. desperatus* var. *conspectus* Barneby]. Perennial, acaulescent or subacaulescent, 1.5–5 cm tall, from a branching caudex; pubescence basifixed; stems 0–5 cm long, mostly obscured by stipules; stipules 2–7 mm long, at least some connate-sheathing; leaves 1.5–5 cm long; leaflets 7–17, 3–9 mm long, 0.9–3.2 mm wide, elliptic to oblanceolate, acute to obtuse, strigose on both sides; peduncles 0.5–5.2 cm long; racemes 2- to 8-flowered, the flowers ascending at anthesis, 0.5–2.5 cm long in fruit; bracts 2–4 mm long; pedicels 0.5–1.5 mm long; calyx 6.1–7.7 (8.4) mm long, the tube 5.2–6.5 mm long; short-cylindric, pilose with mixed black and white hairs, the teeth 0.9–1.7 mm long, subulate; flowers 12.2–15 mm long, pink-purple or bicolored; pods declined, sessile or short-stipitate, ovoid-ellipsoid, curved, 12–19 mm long, 5–6 mm thick, subunilocular, long silky-pilose; ovules ca. 20. Pinyon-juniper woods and mixed desert shrublands on platy shales of the Carmel or on sandstones of Jurassic and Cretaceous ages at 1430 to 1830 m in eastern Garfield and Wayne cos.; Navajo Co., Arizona. The Barneby milkvetch is a near congener of *A. desperatus*, q.v., from which it differs in the larger size of flowers and parts, and in the usually more compact habit of growth; 10 (iv).

***Astragalus beckwithii* Torr. & Gray.** Beckwith Milkvetch. Perennial, caulescent, 5–40 (70) cm tall, from a branching caudex; pubescence basifixed; stems decumbent to ascending or erect; stipules 2–10 mm long, all distinct; leaves 2–15 cm long; leaflets (7) 11–27, 3–17 (25) mm long, 2–9.6 mm wide, orbicular to obovate, obtuse to retuse, glabrous to glabrate on both sides; peduncles 3–15 cm long; racemes 7- to 16-flowered, the flowers ascending at anthesis, the axis 1–7 cm long in fruit; bracts 1–7 mm long; pedicels 1–3.5 mm long; bracteoles 2; calyx 7–9.5 mm long, the tube 3.5–5.7 mm long, short-cylindric, sparingly strigose to glabrous, the teeth 2.5–4.4 mm long, subulate; flowers 14.5–21 mm long, ochroleucous to whitish or pink-purple; pods ascending to declined, stipitate, the stipe (gynophore) 1.5–5 mm long, the body obliquely leathery, unilocular; ovules 18–41. Two distinctive varieties are known in Utah.

1. Flowers pink-purple or bicolored; plants of western Beaver, Juab, and Millard cos. .... *A. beckwithii* var. *purpureus*

— Flowers ochroleucous, concolorous; plants of central to northwestern Utah..... .... *A. beckwithii* var. *beckwithii*

Var. *beckwithii*. [*Tragacantha beckwithii* (Torr. & Gray.) Kuntze; *Phaca beckwithii* (Torr. & Gray.) Piper; *Phacomene beckwithii* (Torr. & Gray.) Rydb.] Juniper-pinyon, sagebrush, bunch-grass, and mountain brush communities at 1330 to 2300 m in Beaver, Carbon, Box Elder, Davis, Millard, Morgan, Piute (US), Salt Lake, Sevier, Tooele, Utah, and Weber cos.; Nevada. Plants of var. *beckwithii* are indistinguishable in anthesis from those of *A. oophorus* var. *caulescens*, with which it is sympatric in part of its range (q.v.); 61 (v).

Var. *purpureus* M. E. Jones. [*A. artemisiarum* M. E. Jones; *Phaca artemisiarum* (M. E. Jones) Rydb.; *Phacomene artemisia-*

rum (M. E. Jones) Rydb.]. Pinyon-juniper and cool-desert shrublands at 1370 to 2200 m in western Beaver, Juab, Millard, and Tooele cos.; Nevada; 24 (5).

Astragalus bisulcatus **(Hook.) A. Gray.** Two-grooved Milkvetch. Perennial, caulescent, 15–70 cm tall, from a caudex; pubescence basifixed; stems erect; stipules 2.5–10 mm long, at least the lowermost connate-sheathing; leaves 3–13.5 cm long; leaflets (7) 15–35, 5–33 mm long, 1.5–11 mm wide, lance-oblong to oblong, elliptic or oblanceolate 2–16 cm long; racemes 25- to 80-flowered, the flowers declined at anthesis, the axis 3–25 cm long in fruit; bracts 2.5–6 mm long; pedicels 1–3.5 mm long; bracteoles 0–2; calyx 3.5–9.6 mm long, gibbous-saccate, the tube 2.8–5.7 mm long, obliquely campanulate, sparingly strigose, the teeth 1–3 mm long, subulate; flowers 8–18 mm long, ochroleucous, whitish, or pink-purple, the keel-tip usually purple; pods pendulous, stipitate, the stipe about equaling the calyx tube, the body ellipsoid, 6.5–20 mm long, 2–4.5 mm thick, dorsiventrally compressed, bisulcate, unilocular, strigose or glabrous; ovules 5–15. The two-grooved milkvetch is an ill-scented primary indicator of selenium in most areas, but non-scented populations are known. Three distinctive varieties are present in Utah.

1. Flowers bright pink-purple; calyx purple; plants of Daggett, Uintah and Grand cos. .... *A. bisulcatus* var. *bisulcatus*

— Flowers ochroleucous or whitish, the keel often purple-tipped; calyx ochroleucous, whitish, or greenish; distribution various 2

2(1). Flowers 8–11 mm long; body of pod 6.5–9.5 mm long, prominently reticulate; plants usually montane in Utah .... *A. bisulcatus* var. *haydenianus*

— Flowers 10–18 mm long; body of pod 10–17 mm long, smooth or faintly reticulate; plants usually not montane .... *A. bisulcatus* var. *major*

Var. *bisulcatus*. [*Phaca bisulcata* Hook.: *Tragacantha bisulcata* (Hook.) Kuntze; *Diholcos bisulcatus* (Hook.) Rydb.]. River terraces at 1530 to 2130 m in Daggett, Grand, and Uintah cos.; Alberta east to Manitoba and south to Idaho, New Mexico, and Kansas; 6 (ii).

Var. *haydenianus* (A. Gray) Barneby. [*A. haydenianus* A. Gray ex Brand.; *Tragacantha haydeniana* (A. Gray) Kuntze; *Diholcos haydenianus* (A. Gray) Rydb.]. Sagebrush-mountain brush communities at 2130 to 2600 m in Carbon, Duchesne, San Juan, Sanpete, Sevier, Uintah, and Utah cos.; Wyoming, Colorado, New Mexico, and Arizona; 16 (v).

Var. *major* (M. E. Jones) Welsh comb. nov. based on *A. haydenianus* var. *major* M. E. Jones Zoe 2: 240. 1891. [*A. scobatinatulus* Sheldon; *Diholcos scobatinatulus* (Sheldon) Rydb.]. Pinyon-juniper, sagebrush, mountain brush, and salt desert shrub at 1530 to 2300 m elevation in Beaver, Garfield, Juab, Kane, Rich, Sanpete, Sevier, and Washington cos.; Wyoming, Colorado, and Arizona. This taxon was included within an expanded var. *bisulcatus* by Barneby (1964), who considered it as being "taxonomically negligible." However, var. *major* differs in about the same manner and degree as do other varieties in *Astragalus*. It is the dominant type within Utah. A population of var. *major* from north of Glendale in western Kane Co., lacks the characteristic odor of selenium commonly associated with all varieties of *A. bisulcatus*; 24 (vii).

Astragalus bodinii **Sheldon.** Bodin Milkvetch. [*Phaca bodinii* (Sheldon) Rydb.; *A. debilis* sensu authors, not A. Gray (?); *A. yukonis* M. E. Jones; *P. yukonis* (M. E. Jones) Rydb.; *A. bodinii* var. *yukonis* (M. E. Jones) B. Boi.]. Perennial, caulescent, 15–80 cm long, from a superficial or buried caudex; pubescence basifixed; stems straggling on other plants; stipules 1–7 mm long all connate-clasping; leaves 2.5–8.5 cm long; leaflets 7–17, 2–12 mm long, 1–7 mm wide, oblanceolate to obovate, ovate or elliptic, rounded to emarginate or acute, strigose beneath, glabrous above; peduncles 1.5–10 cm long; racemes 3- to 15-flowered, the flowers ascending at anthesis, the axis 0.5–9 cm long in fruit; bracts 0.5–2.5 mm long; pedicels 0.7–2.2 mm long; bracteoles 0; calyx 4.5–5.2 mm long, the tube 3.4–3.8 mm long, campanulate, black-strigose, the teeth 1.5–1.8 mm long, subulate; flowers 9.5–10.2 mm long, pink-purple; pods ascending to spreading, stipitate, the stipe (gynophore) to 1 mm long, the body ellipsoid, 5.5–10 mm long, 3–4.5 mm thick, somewhat trigonous, unilocular, strigose; ovules 2–10. Wet meadows at 2000 to 2200 m in Rabbit Valley near Loa, Wayne Co. and along Otter Creek in Piute and Sevier cos.; Alaska east to Newfoundland and south to Alberta and Manitoba, and from Wyoming, Nebraska, and Colorado. Of the great number of species present in Utah, only a handful are true mesophytes. Included in that category are *A. agrestis*, *A. argophyllus* var. *argophyllus*, *A. bodinii*, *A. canadensis*, and *A. diversifolius*. They grow almost exclusively in meadows or other sites which are moist through much of the year. The habitat has been exploited to an extent almost unknown in more arid situations and is seldom explored botanically because of the exploitation, fencing, and private ownership. Despite that exploitation, *A. bodinii* has persisted from its initial discovery by Lester F. Ward (602, US, BRY) in Rabbit Valley, Utah on 18 August, 1875. Possibly *A. bodinii* will yet be found in other meadowlands of the state; 8 (iii).

Astragalus brandegei **T. C. Porter in Port. & Coult.** Brandegee Milkvetch. Perennial, though sometimes flowering as an annual, caulescent, 5–35 (40) cm long, from a branching caudex; pubescence basifixed; stems prostrate-spreading, very slender; stipules 1.5–5 mm long, at least the lowermost usually connate-clasping; leaves 2–11.5 cm long; leaflets 5–15, 6–27 mm long, 0.5–2.6 mm wide, linear-filiform to narrowly oblong, acute to obtuse, strigose beneath, glabrous above; peduncles 2.5–14 cm long, very slender; racemes 1- to 5-flowered, the flowers ascending at anthesis, the axis 0.5–6 cm long in fruit; bracts 1–2 mm long; pedicels 1.2–4 mm long; bracteoles 2; calyx 2.7–4 mm long, the tube 1.8–2.5 mm long, campanulate, black-strigose, the teeth 0.9–2 mm long, subulate; flowers 4.5–6 mm long, ochroleucous or tinged violet; pods pendulous to ascending, sessile or subsessile, the body obovoid to oblong-ellipsoid, 10–18 mm long, 3.5–5 mm thick, slightly dorsiventrally compressed, semibilocular, strigose. Volcanic gravels in mixed shrublands or pinyon-juniper at 1650 to 2430 m in Carbon, Emery (US), Garfield (US), Piute, and Wayne cos.; Colorado, New Mexico, and Arizona. This is a cryptic plant that is seldom collected, probably because of its inconspicuous, tiny flowers, slender peduncles, and slender prostrate stems; 4 (iii).

Astragalus bryantii **Barneby.** Bryant Milkvetch. Perennial, caulescent, 35–80 cm tall, from a caudex; herbage basifixed; stems erect; stipules 3–8 mm long, all distinct; leaves 4–12 cm long; leaflets 11–21, 5–15 mm long, 2–12 mm broad, ovate, obovate, or broadly elliptic, emarginate to truncate, strigose beneath, glabrous above; peduncles 4–10 cm long; racemes 12- to 22-flowered, the flowers spreading-declined at anthesis, the axis 6–13 cm long in fruit; bracts 2–3.5 mm long; pedicels 0.5–3 mm long; bracteoles 0–2; calyx 7–9.3 mm long, the tube 5.1–6.4 mm long, short-cylindric, strigose, the teeth 1.6–3.4 mm long, subulate; flowers 14–19.5 mm long, pink-purple or bicolored; pods spreading-ascending, sessile or subsessile, the body linear to linear-lanceolate in outline, 1.5–3 cm long, 3–5 mm thick, laterally compressed, bilocular, strigose, to glabrous; ovules 22–27. Talus slopes in mixed desert shrub communities at 770 to 1070 m in Lost Eden and West Creek canyons, Glen Canyon, San Juan Co.; Grand Canyon, Arizona. The low elevation reaches of Glen Canyon are flooded almost to the 1128.5 m level by the water of Lake Powell, and it seems probable that the Bryant milkvetch is extinct in Utah. The plants simulate *A. lentiginosus* var. *palans*, but differ in pod characters; 1 (0).

Astragalus callithrix **Barneby.** Callaway Milkvetch. Perennial, subacaulescent, 2–11 cm tall, from a caudex; pubescence basifixed; stems lacking or to 10 cm long, prostrate, the internodes often concealed by stipules; stipules 2–5 mm long, all distinct, leaves 2–11 cm long; leaflets 9–21, 2–13 mm long, 1.5–10 mm wide, obovate, suborbicular, or lanceolate, obtuse to truncate or emarginate, villous on both sides; peduncles 2–8 (12) cm long; racemes 5- to 15-flowered, the flowers ascending at anthesis, the axis 0.5–6 cm long in fruit; bracts 3–7.5 mm long; pedicels 1–1.5 mm long; bracteoles 0–2; calyx 6.8–13.3 mm long, the tube 5.5–10.8 mm long, cylindric, villous-pilose, purplish, the teeth 1–3.2 mm long; flowers bright pink-purple, 16–26 mm long; pods ascending-spreading, sessile, oblong-ovoid, 10–20 mm long, 5–7.5 mm thick, dorsiventrally compressed, curved, long hairy (the valves not obscured), unilocular; ovules 24–34. Sandy flats and dunes in mixed desert shrublands at 1550 to 1625 m in western Millard Co.; Nye Co., Nevada; a Great Basin endemic; 3 (0).

Astragalus calycosus **Torr. ex S. Wats.** Torrey Milkvetch. Perennial, low, acaulescent, 1–12 cm tall, from a branching caudex; pubescence malpighian; stems lacking or to 2 cm long, the internodes concealed by stipules; stipules 1.5–6 mm long, all distinct; leaves 1–8 (12) cm long; leaflets (1) 3–13, 2–19 mm long, 1–7 mm wide, obovate, oblanceolate, or elliptic, obtuse to acute, silvery strigose on both sides; peduncles 0.5–10 cm long, rarely longer; racemes 1- to 8-flowered, the flowers ascending to spreading at anthesis, the axis 0.2–2.5 cm long in fruit; bracts 0.5–2 mm long; pedicels 0.7–3 mm long; bracteoles 0–2; calyx 5–8.5 mm long, the tube 4–6.7 mm long, campanulate to shortly-cylindric, strigose, the teeth 1–4.2 mm long, subulate; flowers 10–16.5 mm long, varicolored, ochroleucous to shades of pink and purple, with white or pale wing-tips, the wings bilobed apically; pods ascending, sessile, narrowly oblong, usually curved, 8–25 mm long, 3–45 mm thick, laterally compressed, bilocular, strigose. Rather widespread and distinctive, the plants of Torrey milkvetch are separable into three varieties, two rare and one common.

1. Leaves with 5–13 leaflets along a rachis usually more than 1 cm long; scapes erect-ascending, usually over 7 cm long; raceme axis usually more than 2 cm long; plants of Washington Co. .... *A. calycosus* var. *scaposus*

— Leaves with 3–13 leaflets along a rachis less than 1 cm long; scapes ascending to decumbent, 1–7 cm long; raceme axis less than 2 cm long; distribution various 2

2(1). Leaflets 7–13, mostly 2–6 mm long; alpine plants of extreme west-central Utah, rare .... *A. calycosus* var. *mancus*

— Leaflets 3–7, mostly 5–19 mm long; plants of lower elevations, widespread, except in the northeastern third of Utah .... *A. calycosus* var. *calycosus*

Var. *calycosus*. [*Tragacantha calycosa* (Torr.) Kuntze; *Hamosa calycosa* (Torr.) Rydb.; *A. brevicaulis* A. Nels.]. Mixed desert shrublands, pinyon-juniper, and ponderosa pine communities at 1430 to 2730 m in Beaver, Box Elder, Emery, Garfield, Iron, Juab, Kane, Millard, San Juan, Sanpete, Sevier, Tooele, Utah, Washington and Wayne cos.; Wyoming, Idaho, Nevada, California, and Arizona; 92 (xviii).

Var. *mancus* (Rydb.) Barneby. [*Hamosa manca* Rydb.; *A. mancus* (Rydb.) Wheeler.] Ridgetops at 2650 to 3660 m in Deep Creek Mts., Juab Co.; Nevada; 5 (i).

Var. *scaposus* (A. Gray) M. E. Jones. (*A. scaposus* A. Gray; H. *scaposa* (A. Gray) Rydb.; *A. candicans* Greene. Ridgetops at ca. 2730 m in Beaverdam Mts., Washington Co.; Nevada, Arizona, Colorado, and New Mexico; 1 (0).

Astragalus canadensis **L.** Canada Milkvetch. Perennial, caulescent, 15–120 cm tall, erect or ascending; stipules 3–12 mm long or more, at least the lowermost connate-sheathing; leaves 5–30 cm long; leaflets 13–35, 10–52 mm long, 6–16 mm wide, lanceolate, lance-oblong, or elliptic, obtuse to emarginate, strigose on both sides or glabrous above; peduncles 4–22 cm long; racemes many-flowered, the flowers spreading-declined in anthesis, the axis 2.5–16 cm long in fruit; bracts 1.5–10 mm long; pedicels 0.5–3.5 mm long; bracteoles 0–2; calyx 4.6–10.5 mm long, the tube 4–8.5 mm long, short-cylindric, strigose, the teeth 1.2–4.4 mm long, subulate or triangular; flowers 13.5–17.5 mm long, ochroleucous; pods erect, sessile or subsessile, cylindroid, 10–20 mm long, 2.9–5.2 mm thick, bilocular, strigose or glabrous; ovules 16–28. Two varieties of Canada milkvetch are known from Utah. These are peculiar among our many low-elevation species in flowering in midsummer.

1. Pods and ovaries glabrous, terete at maturity, not sulcate dorsally; calyx teeth 2.5–4.1 mm long; plants mostly 40–120 cm tall .... *A. canadensis* var. *canadensis*

— Pods and ovaries pubescent, sulcate dorsally at maturity; calyx teeth mostly 1–2.5 mm long; plants 10–50 cm tall .... *A. canadensis* var. *brevidens*

Var. ***brevidens*** **(Gand.) Barneby.** [*A. mortonii* f. *brevidens* Gand.]. Meadows, stream banks, lake shores, and hillsides at 1830 to 2300 m in Box Elder, Cache, Daggett, Rich, Summit, and disjunctly in Washington cos.; Montana, Idaho, Oregon, California, Nevada, Wyoming, and Colorado; 10 (iii).

Var. ***canadensis.*** [*A. carolinianus* L.]. Stream terraces and lake shores at 1370 to 1600 m in Cache, Piute (Rydberg & Carlton 6967, 20 July 1905, Sevier River below Marysvale, US), Salt Lake, Utah, and Wasatch cos.; British Columbia east to Ontario and south to Washington, New Mexico, Texas, Louisiana, Alabama, and South Carolina; 6 (i).

Astragalus ceramicus **Sheldon.** Painted Milkvetch. [*Phaca picta* A. Gray; *A. pictus* (A. Gray) A. Gray, not Boiss. & Gaill.; *A. pictus* var. *foliolosus* A. Gray; *Tragacantha picta* (A. Gray) Kuntze; *A. angustus* var. *pictus* (A. Gray) M. E. Jones; *A. angustus* var. *ceramicus* (Sheldon) M. E. Jones; *A. pictus* var. *angustus* M. E. Jones, type from Montezuma Canyon; *A. ceramicus* var. *jonesii* Sheldon; *A. angustus* (M. E. Jones) M. E. Jones; *A. pictus* var. *magnus* M. E. Jones, type from Silver Reef.]. Perennial, caulescent, 3–40 cm tall, from elongate rhizome-like caudex branches and deeply-buried caudex; pubescence malpighian, stems sprawling to erect; stipules 1.5–9 mm long, at least some connate-sheathing; leaves 2–17 cm long; leaflets 3–13 or only one, the terminal continuous with the rachis, 3–30 mm long, 0.5–3 mm wide, filiform to narrowly oblong, obtuse to retuse or acute; peduncles 0.7–7.5 cm long; racemes 2- to 15-flowered (rarely more), the flowers ascending to declined at anthesis, the axis 1–12 cm long in fruit; bracts 1–2.5 mm long; pedicels 0.7–3.1 mm long; bracteoles 0; calyx 3.1–4.2 mm long, the tube 2.1–3.3 mm long, campanulate, strigose, the teeth 1–2.4 mm long, subulate; flowers 6.3–9.5 mm long, dull purplish to pink, or rarely whitish; pods pendulous, stipitate, the stipe 1–3.3 mm long, the body bladdery-inflated, ellipsoid to ovoid, 12–30 mm long, usually mottled, glabrous, unilocular; ovules 12–29. Sandy soils in pinyon-juniper, sagebrush, stream bank, grassland, and mixed desert shrub communities at 1270 to 2360 m in Beaver, Emery, Garfield, Grand, Juab, Kane, San Juan, Tooele, Uintah, Wayne, and Washington cos.; Colorado, New Mexico, Arizona. Our materials belong to **var.** ***ceramicus***; 40 (x).

Astragalus chamaeleuce **A. Gray in Ives.** Cidada Milkvetch. [*Phaca pygmaea* Nutt.; *Tragancantha pygmaea* (Nutt.) Kuntze; *A. cicadae* var. *laccoliticus* M. E. Jones, type from Henry Mts.; *A. pygmaeus* var. *laccoliticus* (M. E. Jones) M. E. Jones.]. Perennial, acaulescent to subacaulescent, 2–10 cm tall, from a caudex; pubescence malpighian; stems lacking or to 6 cm long and prostrate, the internodes mostly obscured by the stipules; stipules 2–7 mm long, all distinct; leaves 2–10 cm long; leaflets 5–17, 4–15 mm long, 2–10 mm wide, obovate to oblanceolate, obtuse to truncate or emarginate, strigose on both sides; peduncles 1–8 cm long; racemes 2- to 11-flowered, the flowers spreading-ascending, the axis 0.9–2 cm long in fruit; bracts 2–5 mm long; pedicels 1–3.5 mm long, short-cylindric, strigose, the teeth 1.5–2.9 mm long; flowers ochroleucous or tinged purplish to pink-purple; pods ascending, sessile, oblong-ovoid or ellipsoid, 2–4 cm long, 7–16 mm thick, the fleshy valves ca. 3 mm thick, shrinking in ripening, the papery exocarp ultimately lustrous, separating from the veins beneath and appearing quite smooth, mottled, strigose, unilocular; ovules 37–46. Juniper-pinyon, sagebrush, mixed desert shrub, and grassland communities at 1530 to 2130 m in Daggett, Duchesne, Emery, Garfield, Grand, and Uintah cos.; Colorado and Wyoming. The cicada milkvetch is the only subacaulescent species of *Astragalus* of its type with malpighian hairs known from the Uinta Basin. To the south of there it is rare, but mingles with both *A. amphioxys* and *A. cymboides*, and mature fruit is necessary for positive identification of *A. chamaeleuce* from those entities; 29 (x).

Astragalus chloodes **Barneby.** Grass Milkvetch. Perennial, acaulescent or subacaulescent, 5–24 cm tall, from a branching caudex; pubescence malpighian; stems obscured by stipules; stipules 2–8 mm long, all usually connate-sheathing; leaves simple, 1–13 (17) cm long, 1–3 mm wide, flat or involute, strigose on both sides; peduncles 2–9 cm long; racemes loosely 7- to 23-flowered, the flowers ascending at anthesis, the axis 4.5–24 cm long in fruit; bracts 2–4.5 mm long; pedicels 1–2.5 mm long; bracteoles 0; calyx 4.5–8.5 mm long, the tube 2–3 mm long, campanulate, strigose, the teeth 2.5–5.2 mm long, rigid-spreading; flowers 6.2–8.2 mm long, pink-purple; pods erect or ascending, sessile, obliquely lanceolate or oblong in outline, curved, 8–12 mm long, 1.7–3 mm wide, glabrous or strigose, unilocular; ovules 4–8. Entrada Sandstone (or less commonly on Navajo Sandstone) hogbacks and cuestas in pinyon-juniper and mixed desert shrub communities at 1450 to 1700 m in Uintah Co.; endemic. The grass milkvetch simulates a grass, not only in its narrow leaves, but also in the flowers in bud which resemble grass spikelets; 11 (ii).

Astragalus cibarius **Sheldon.** Browse Milkvetch. [*A. webberi* var. *cibarius* (Sheldon) M. E. Jones; *Xylophacos cibarius* (Sheldon) Rydb.; *A. arietinus* M. E. Jones, type from Cedar City.]. Perennial, caulescent, 6–30 cm tall, from a branching caudex; pubescence basifixed; stems decumbent to ascending; stipules 3–8 mm long, all distinct; leaves 3.5–10 cm long; leaflets 11–19, 4–17 mm long, 2–13 mm wide, obovate, oblong, oblanceolate, obtuse or retuse, strigose beneath, glabrous above; peduncles 3–8 cm long; racemes 4- to 14-flowered, subcapitate at early anthesis, the flowers spreading-ascending, the axis 0.5–2.7 cm long in fruit; bracts 2–4 mm long; pedicels 1–2.5 mm long; bracteoles 0–2; calyx 6.4–9.2 mm long, the tube 5–7 mm long, cylindric, strigose, the teeth 1.4–2.5 mm long; flowers 15–19 mm long, pink-purple with white wing-tips or whitish to ochroleucous and variously tinged; pods ascending, subsessile, ellipsoid to oblong, 17–32 mm long, 7–10 mm thick, curved to almost straight, strigose, unilocular, woody or stiffly leathery; ovules 27–32. Mountain brush, sagebrush, juniper-pinyon, and mixed desert shrub communities at 1630 to 2430 m in Beaver, Box Elder, Cache, Davis, Garfield, Iron, Juab, Millard, Morgan, Salt Lake, Sanpete, Sevier, Summit, Tooele, Utah, Wasatch, Washington, and Weber cos.; Nevada, Idaho, Montana, Wyoming, and Colorado. The browse milkvetch is allied to *A. ensiformis* and *A. malacoides*, but is easily distinguished from them both morphologically and geographically; 108 (xiv).

Astragalus cicer **L.** Chickpea Milkvetch. [*Cystium cicer* (L.) Stev.]. Perennial, caulescent, 20–70 cm tall or more, from a branching caudex; pubescence basifixed; stems prostrate to ascending; stipules 2–8 mm long, at least the lowermost connate-sheathing; leaves 4–21 cm long; leaflets 17–27 (31), 5–40 mm long, 2–14 mm wide, lance-elliptic to oblong, acute to obtuse, strigose on both sides or glabrous above; peduncles 4–12 cm long; racemes densely 10- to 30-flowered, the flowers ascending at anthesis, the axis 2–7 cm long in fruit; bracts 2–6.5 mm long; pedicels 0.3–1.5 mm long; bracteoles 0; calyx 6–9 mm long, the tube 5–6 mm long, short-cylindric, strigulose, the teeth 1.6–3 mm long; flowers 12.5–16.5 mm long, ochroleucous; pods ascending, or by crowding, spreading, subsessile, the body ovoid or subglobose, strongly inflated, 6–14 mm long, 6–10 mm thick, pilose, bilocular. Introduced forage plant, escaping and persisting in pinyon-juniper, sagebrush, and aspen communities at 1770 to 2170 m in Sanpete Co., and to be expected elsewhere; indigenous to Europe; 3 (0).

***Astragalus coltonii* M. E. Jones.** Colton Milkvetch. Perennial, caulescent, 10–75 cm tall, from a branching caudex; pubescence basifixed; stems erect or ascending; stipules 1–7 mm long, all distinct; leaves 2–10 cm long; leaflets 3–19, or the uppermost leaves simple, 3–20 mm long, 0.3–3 mm wide, linear, narrowly oblong, or ovate, strigose on both sides; peduncles 4–30 cm long; racemes loosely 5- to 30-flowered, the flowers spreading-declining at anthesis, the axis 3–28 cm long in fruit; bracts 0.5–3.2 mm long; pedicels 0.8–2.5 mm long; bracteoles 0; calyx 4.5–8 mm long, the tube 4–6.7 mm long, cylindric, strigose, purplish, the teeth 0.6–2.3 mm long, broadly subulate; flowers 12–19 mm long, pink-purple; pods pendulous, stipitate, the stipe 4–11 mm long, the body oblong to oblanceolate in outline, 19–35 mm long, 3–6 mm wide, strongly laterally flattened, glabrous, unilocular; ovules 14–20. Two allopatric and distinctive varieties of Colton milkvetch occur in Utah.

1. Leaves all odd-pinnate, with 9–19 leaflets, the terminal one jointed on all leaves; plants of Grand and San Juan cos. .... *A. coltonii* var. *moabensis*

— Leaves odd-pinnate, or the uppermost simple, with 3–9 leaflets, the terminal one continuous with the rachis; plants not from Grand or San Juan cos. .... *A. coltonii* var. *coltonii*

Var. *coltonii*. [*Homalobus coltonii* (M. E. Jones) Rydb.; *A. coltonii* var. *aphyllus* M. E. Jones, type from Richfield.]. Bunchgrass, salt desert shrub, pinyon-juniper, and mountain brush communities at 1470 to 2300 m in Carbon (type from Castle Gate), Emery, Garfield, Kane, Sevier, and Wayne cos.; endemic; 38 (ix).

Var. *moabensis* M. E. Jones. [*A. coltonii* var. *foliosus* M. E. Jones ex A. Eastwood; *Homalobus canovirens* Rydb., type from LaSal Mts.; *A. canovirens* (Rydb.) Barneby.]. Pinyon-juniper and less commonly mountain brush communities at 1400 to 2300 m in Grand and San Juan (type from Monticello) cos.; Colorado, New Mexico, and Arizona; 21 (viii).

***Astragalus consobrinus* (Barneby) Welsh** comb. nov. based on *A. castaneiformis* var. *consobrinus* Barneby Amer. Midl. Nat. 41: 496. 1949. Bicknell Milkvetch. Perennial, sometimes flowering the first year, acaulescent, 1–5 cm tall, the caudex branches obscured by persistent leaf bases and stipules; herbage malpighian; stems essentially lacking; stipules 3–7 mm long, all distinct; leaves 1–5 cm long; leaflets 3–11, 2–8 mm long, 1.5–4.2 mm wide, obovate to oblanceolate or orbicular, rounded to obtuse or acute, strigose on both surfaces; peduncles 0.5–3 cm long; racemes 2- to 10-flowered, the flowers ascending at anthesis, the axis to 1 cm long in fruit; bracts 1.5–3.5 mm long; pedicels 1–2 mm long; bracteoles 0; calyx 5.5–8.9 mm long, the tube 4.1–6.8 mm long, cylindric, strigose, the teeth 1.4–1.7 mm long, subulate; flowers 10–15.5 mm long, ochroleucous suffused with purple; pods ascending, sessile, obliquely ovoid or lance-ovoid, 11–19 mm long, 3–8 mm thick, strigose, unilocular; ovules 18–33. Sagebrush-grasslands and pinyon-juniper communities at 1830 to 2200 m in Emery, Garfield, Piute, Sevier, and Wayne cos.; endemic. The Bicknell milkvetch has been compared with and treated within an expanded *A. castaneiformis*, with which it is similar in some salient morphological features. The similarity appears to be at least in part coincidental, and the true relationship of the Bicknell plants might lie with *A. cymboides* with which it is apparently allied. In any event, it seems best to treat *A. consobrinus* at specific level; 7 (v).

Astragalus convallarius **Greene.** Lesser Rushy Milkvetch. Perennial, caulescent, 10–60 cm tall, from a subterranean caudex; pubescence basifixed; stems erect or ascending; stipules 2–7 mm long, at least the lowermost connate-sheathing; leaves 2–11 cm long; leaflets, when present, 3–13, the uppermost leaves reduced to the rachis, mostly 5–30 mm long, 0.5–4 mm wide, linear to oblong or oblanceolate; peduncles 1–14 cm long; racemes 3- to 25-flowered, the flowers ascending to declined at anthesis, the axis 2–20 cm long in fruit; bracts 0.5–2.3 mm long; pedicels 1–8 mm long; bracteoles 0–2; calyx 4–6.3 mm long, the tube 3.4–5.4 mm long, campanulate, black strigose, the teeth 0.5–1.4 mm long, triangular-subulate; flowers 6.5–12 mm long, ochroleucous or variously tinged or veined with purple; pods pendulous to spreading, sessile, linear to narrowly oblong, straight, 13–50 mm long, 2.3–4 mm thick, laterally compressed, strigose, unilocular; ovules 11–26. This is possibly the most widespread of the milkvetch species within Utah, definitely known from all but two counties. Two allopatric varieties are present.

1. Pods 25–50 mm long, 2.3–3.3 mm wide; plants widespread but not in western Iron and Washington cos. .... *A. convallarius* var. *convallarius*

— Pods 13–26 mm long, 3.4–4 mm wide; plants of western Iron and Washington cos. .... *A. convallarius* var. *finitimus*

Var. *convallarius.* [*Homalobus campestris* Nutt. ex Torr. & Gray: *Tragacantha campestris* (Nutt.) Kuntze; *A. serotinus* var. *campestris* (Nutt.) M. E. Jones *Phaca convallaria* (Nutt.) Greene; *H. junceus* Nutt. ex Torr. & Gray; *A. junceus* (Nutt.) A. Gray, not Ledeb. ex Spreng.; *T. juncea* (Nutt.) Kuntze; *A. diversifolius* var. *junceus* (Nutt.) M. E. Jones; *A. diversifolius* var. *roborum* M. E. Jones; *A. junciformis* A. Nels.; *H. junciformis* (A. Nels.) Rydb.; *A. junceus* var. *attenuatus* M. E. Jones, type from Price]. Mixed desert shrub, sagebrush, pinyon-juniper, mountain brush, ponderosa pine, and aspen communities at 1400 to 2900 m in all except Grand and Rich cos., and likely there also; Idaho and Montana south to Nevada and Colorado; 139 (xxiv).

Var. *finitimus* **Barneby.** Pinyon-juniper and sagebrush communities at 1700 to 2270 m in western Iron and Washington cos.; Lincoln Co., Nevada; 7 (ii).

Astragalus cottamii **Welsh.** Cottam Milkvetch. Perennial, sometimes flowering the first year, acaulescent or subacaulescent, 1.2–8 cm tall, from a branching caudex; pubescence basifixed; stems lacking, or 0.5–6 cm long, the internodes mostly obscured by stipules; stipules 2–6 mm long, all distinct; leaves 1.2–8 cm long; leaflets (5) 9–19 (21), 2–9 mm long, 1–4.2 mm wide, elliptic to oval or oblanceolate, acute to obtuse, strigose on both sides or glabrate above; peduncles 0.7–7 cm long; racemes 3- to 9-flowered, the flowers ascending at anthesis, the axis 0.5–2 cm long in fruit; bracteoles 0–2; calyx 6.2–8 mm long, the tube 4.8–6.7 mm long, cylindric, strigulose, purplish, the teeth 1.2–2 mm long, subulate; flowers 11–17 mm long, pink-purplish or bicolored; pods spreading-descending, sessile, curved, oblong to oblong-lanceolate in outline, triquetrous, the dorsal suture sulcate, bilocular, strigose, usually purple-blotched. Rimrock and ledges of Cedar Mesa, Kayenta, and Entrada sandstones, and in the sandy canyons cut from them in pinyon-juniper woods and blackbrush at 1300 to 1400 m in San Juan Co.; Navajo Co., Arizona. The Cottam milkvetch was not distinguished among the limited collections available to Barneby (1964), where the few specimens were thought to represent a portion of the range variability within *A. monumentalis.* The rather larger set currently available allows segregation on the basis of easily discernible diagnostic features of flowers and fruit; 11 (ix).

Astragalus cronquistii **Barneby.** Cronquist Milkvetch. Perennial, caulescent 1.5–4 cm long, from a subterranean caudex; pubescence basifixed; stems decumbent-ascending; stipules 2–6 mm long, all distinct; leaves 1.5–4.5 cm long; leaflets 7–15, 6–23 mm long, 1.5–4 mm wide, oblong to narrowly elliptic, retuse to truncate, strigose beneath, glabrate above; peduncles 2–6.5 cm long; racemes 6- to 20-flowered, the flowers declined at anthesis, the axis 1.5–8.5 cm long in fruit; bracts 0.6–1.2 mm long; pedicels 1.5–2.5 mm long; bracteoles 0; calyx 3.8–5.3 mm long, the tube 3.3–4 mm long, campanulate, strigose, the teeth 0.5–1.3 mm long, triangular; flowers 8–9 mm long, pink-purple; pods declined-pendulous, sessile or subsessile, the body narrowly elliptic to oblanceolate in outline, 13–30 mm long, 3–4.8 mm wide, trigonous, grooved dorsally, strigose, semibilocular. Blackbrush community, on Cutler Formation, at 1430 m in San Juan Co.; endemic; 4 (ii).

Astragalus cymboides **M. E. Jones.** Canoe Milkvetch. [*Xylophacos cymboides* (M. E. Jones) Rydb.; *A. amphioxys* var. *cymbellus* M. E. Jones]. Perennial, acaulescent or subacaulescent, 2.5–8 cm tall, from a simple or branched caudex; pubescence malpighian; stems lacking or 0.5–3 cm long, the internodes mostly obscured by stipules; stipules 3–8 mm long, all distinct; leaves 2.5–8 cm long; leaflets (1–3) 5–13, 3–13 mm long, 2–9 mm wide, obovate, elliptic or oblanceolate, obtuse to acute, pubescent on both surfaces; peduncles 2–8 cm long; racemes 3- to 9-flowered, the flowers ascending at anthesis, the axis 0.5–2 cm long in fruit; bracts 1–4 mm long; pedicels 0.7–2.5 mm long; bracteoles 0; calyx 7.6–10.2 mm long, the tube 5.9–8 mm long, cylindric, strigose, the teeth 1–2.3 mm long, subulate; flowers 15–18.5 mm long, ochroleucous or suffused purplish, or pink-purple; pods ascending, sessile, oblong to oblong-elliptic in outline, straight, 17–30 mm long, 6–9.5 mm wide, laterally compressed, the valves stiffly papery or cellular-spongy, the exocarp in time exfoliating, strigose, unilocular; ovules 39–57. Salt desert shrub and pinyon-juniper communities at 1600 to 2300 m in Carbon, Emery, and Grand cos.; endemic. The small-flowered phases of canoe milkvetch approach *A. consobrinus* and the large-flowered phases are difficult to distinguish from *A. amphioxys*. Further work is indicated; 36 (vii).

Astragalus desereticus **Barneby.** Deseret Milkvetch. Perennial, acaulescent or subacaulescent, 4–11 cm tall, from a caudex; pubescence basifixed; stems to 5 cm long, the nodes mostly obscured by stipules; stipules 3.5–7 mm long, all distinct; leaves 4–11 cm long; leaflets 11–17, 2–10 mm long, elliptic to obovate, short-acuminate to acute, strigulose-villosulous on both sides; peduncles 2–5.5 cm long; racemes 5- to 10-flowered, the flowers ascending at anthesis, the axis 0.5–2 cm long in fruit; bracts 3–6 mm long; pedicels 2–3 mm long; bracteoles 0–2; calyx 8.4–11.5 mm long, the tube 6.2–7.5 mm long, cylindric, villous, the teeth 2–4 mm long, subulate; flowers 18–22.5 mm long, ochroleucous (?), the keel purple-tipped; pods ascending, sessile or substipitate, ovoid-ellipsoid, curved, 10–12 mm long, 4–5 mm thick, densely hirsute with lustrous hairs; ovules 14–16. Sagebrush or pinyon-juniper communities at 1830 to 2000 m at Indianola, Sanpete Co.; endemic. This is an obscure taxon, apparently with affinities to *A. argophyllus* var. *martinii*, but differing in its densely long-hirsute and small pods. The Deseret milkvetch differs further in its more strongly graduated petals (banner 18–22.5 mm, but the keel 12–13.3 mm long). More material is necessary to make adequate predictions as to the true nature of this entity. It has not been collected in more than half a century; 1 (0).

Astragalus desperatus **M. E. Jones.** Rimrock Milkvetch. [*Batidophaca desperata* (M. E. Jones) Rydb.; *Tium desperatum* (M. E. Jones) Rydb.; *A. desperatus* var. *petrophilus* M. E. Jones, type from San Rafael Swell; *B. petrophila* (M. E. Jones) Rydb.]. Perennial, acaulescent or subacaulescent, 1–12 cm tall, from a branching caudex; pubescence basifixed; stems to 8 cm long, the internodes often obscured by stipules; stipules 1.5–7 mm long, at least some connate-sheathing; leaves 1–12 cm long; leaflets 7–17, 2–13 mm long, 1–5 mm wide, elliptic to oblanceolate or obovate, acute to obtuse, strigose on both sides or glabrate above; peduncles 0.5–13 cm long; racemes 3- to 18-flowered, the flowers ascending to declined at anthesis, the axis 0.4–13 cm long in fruit; bracts 1.5–5 mm long; pedicels 0.5–1.4 mm long; bracteoles 0–2; calyx 3.5–6 mm long, the tube 2.5–4 mm long, campanulate, strigose-pilose, the teeth 0.8–2.6 mm long, subulate; flowers 6–9 mm long, pink-purple or bicolored; pods declined to deflexed, sessile or short-stipitate, the stipe (gynophore) to 1.2 mm long, the body obliquely ovoid to lance-ellipsoid, curved, 6–19 mm long, 3–6 mm thick, hirsute with lustrous hairs, unilocular; ovules 16–28. Mixed desert shrub and pinyon-juniper communities, often on rimrock, at 1130 to 1900 m in Emery, Garfield, Grand, Kane, San Juan, and Wayne cos.; Colorado and Arizona; Colorado Plateau endemic. There is some variation within *A. desperatus*. The deep pink-purple, small flowers with dark purplish calyces displayed by plants of the interior and northern half of the San Rafael Swell are the most distinctive of the variant types. These apparently form the basis of var. *petrophila* M. E. Jones. Further collections might demonstrate the necessity for recognition of that variety; 66 (xxi).

***Astragalus detritalis* M. E. Jones.** Debris Milkvetch. [*Homalobus detritalis* (M. E. Jones) Rydb.; *A. spectabilis* C. L. Porter, not Schischk., the type from southwest of Vernal]. Perennial, acaulescent, 0.5–8 cm long, from a branching caudex; pubescence malpighian; stems essentially lacking; stipules 3–10 mm long, at least some (usually all) connate-sheathing; leaves 0.5–8 cm long, simple or leaflets 3–7, 3–30 mm long, and 0.5–2.5 mm wide, narrowly oblanceolate to linear, spinulose-tipped, strigose on both sides; peduncles 1–9 cm long; racemes 2- to 8-flowered, the flowers ascending at anthesis, the axis 0.2–3.8 cm long; bracts 2.5–7 mm long; pedicels 0.5–2.5 mm long; bracteoles 0–2; calyx 5–9.6 mm long, the tube 3.1–5.4 mm long, campanulate, strigose, the teeth 1.6–4.7 mm long, subulate; flowers 13–20 mm long, pink-purple; pods erect to steeply ascending, sessile, narrowly oblong, straight to curved, 15–38 mm long, 2–3.5 mm wide, laterally compressed, mottled, strigose, unilocular; ovules 15–24. Pinyon-juniper and mixed desert shrub communities at 1650 to 1950 m in Duchesne (type from southwest of Duchesne) and Uintah cos.; Rio Blanco Co., Colorado; a Unita Basin endemic; 10 (ii).

***Astragalus diversifolius* A. Gray.** Meadow Milkvetch. [*Homalobus orthocarpus* Nutt. ex Torr. & Gray, not Boiss.; *A. campestris* var. *diversifolius* (A. Gray) Macbr.; *A. junceus* var. *orthocarpus* (Nutt.) M. E. Jones; *A. junceus* var. *diversifolius* (A. Gray) M. E. Jones; *A. convallarius* var. *diversifolius* (A. Gray) Tidestr.; *A. ibapensis* M. E. Jones; *Atelophragma ibapense* (M. E. Jones) Rydb.]. Perennial, caulescent, 20–50 cm long, from a subterranean to superficial caudex; pubescence basifixed; stems prostrate to ascending; stipules 1–3 mm long, the lowest connate-sheathing; leaves 1.5–7 cm long; leaflets 1–7, 4–47 (67) mm long, narrowly elliptic, linear, oblanceolate or lanceolate, the uppermost often simple, strigose on both sides; peduncles 2–15 cm long; racemes 3- to 8-flowered, the flowers ascending at anthesis, the axis 0.5–3 mm long in fruit; bracts 0.7–2.5 mm long; pedicels 1.8–4 mm long; bracteoles 0; calyx 4.4–6.7 mm long, the tube 3.2–4.7 mm long, campanulate, strigose, the teeth 1–2 mm long, subulate; flowers 8–13.5 mm long, greenish-white, often tinged with purple; pods ascending to declined, sessile or substipitate, the body narrowly oblong, 10–17 mm long, 2.7–4 mm wide, strongly compressed, strigose, unilocular; ovules 10–16. Moist, often saline, meadows at 1340 to 1700 m in Juab (Juab, Goodding 1084, GH, NY, US, June 10, 1902), and Tooele (type of *A. ibapensis* from Deep Creek Mts., M. E. Jones s.n., 23 June 1891, POM); Idaho. This is a poorly known entity in Utah, and it is not known from recent collections. Possibly it is extinct in Utah; 1 (0).

***Astragalus drummondii* Douglas ex Hook.** Drummond Milkvetch. [*Tragacantha drummondii* (Douglas) Kuntze; *Tium drummondii* (Douglas) Rydb.]. Perennial, caulescent, 25–60 cm tall, from a branching subterranean caudex; pubescence basifixed; stems erect or ascending; stipules 3–12 mm long, at least some connate-sheathing; leaves 4–13 cm long; leaflets 17–33, 4–33 mm long, 2–12 mm wide, oblong to oblanceolate or obovate, obtuse to truncate or emarginate, villous-pilose beneath, usually glabrous above; peduncles 4–12 cm long; racemes 14- to 30-flowered, the flowers spreading-declined at anthesis, the axis 3–22 cm long in fruit; bracts 2–5 mm long; pedicels 1.5–5 mm long; bracteoles 0–2; calyx 7–12.5 mm long, the tube 4.7–8 mm long, short-cylindric, sparingly villous, the teeth 1.7–4.5 mm long, subulate; flowers 18–26 mm long, whitish to ochroleucous, the keel purple-tipped; pods pendulous, stipitate, the stipe 5–11 mm long, the body narrowly oblong to oblanceolate in outline, 17–32 mm long, 3.5–5.5 mm thick, trigonous, sulcate dorsally, glabrous, bilocular; ovules 14–30. Pinyon-juniper, ponderosa pine, and mountain brush communities at 1530 to 2130 m in Beaver, Sevier, and Utah cos.; Alberta and Saskatchewan south to New Mexico; 12 (ii).

***Astragalus duchesnensis* M. E. Jones.** Duchesne Milkvetch. [*Lonchophaca duchesnensis* (M. E. Jones) Rydb.]. Perennial, caulescent, 15–35 cm tall, from a branching caudex; pubescence basifixed; stems straggling to ascending or erect; stipules 3–8 mm long, all distinct; leaves 2–10 cm long; leaflets 5–15, 3–20 mm long, 0.5–3 mm wide, linear to oblong or narrowly oblanceolate, obtuse to retuse, strigose on both sides or glabrate above, the uppermost leaflet sometimes continuous with the rachis; peduncles 3–10.5 cm long; racemes 6- to 22-flowered, the flowers ascending at anthesis, the axis 2.5–12 cm long in fruit; bracts 0.7–2 mm long; pedicels 0.8–2.2 mm long; bracteoles 0; calyx 3.6–5.5 mm long, the tube 3.1–4.3 mm long, campanulate, usually purple, the teeth 0.4–1mm long, triangular; flowers 8.5–12.5 mm long, pink-purple with white wing-tips; pods declined sessile, oblong to narrowly oblanceolate in outline, 20–35 mm long, 3.3–5 mm thick, dorsiventrally compressed in the lower half, becoming laterally compressed in the distal portion, strigose, unilocular; ovules 21–31. Sand to heavy clay soils in mixed desert shrub and pinyon-juniper communities at 1450 to 1750 m in Duchesne and Uintah cos., endemic; 7 (ii).

***Astragalus eastwoodae* M. E. Jones.** Eastwood Milkvetch. [*A. preussii* var. *sulcatus* M. E. Jones; *Phaca eastwoodae* (M. E. Jones) Rydb.; *A. preussii* var. *eastwoodae* (M. E. Jones) M. E. Jones.]. Perennial, short caulescent, 8–20 cm tall, from a branching caudex; pubescence lacking except on calyx, basifixed; stems 2–14 cm long, decumbent to ascending; stipules 2–6.5 mm long, all distinct; leaves 3–13 cm long; leaflets 13–25, 1–15 mm long, 1–5 mm broad, elliptic to lance-elliptic, oblanceolate or obovate, obtuse to truncate-emarginate, glabrous; peduncles 2–10.5 cm long; bracts 1.5–4.5 mm long; pedicels 1.5–3.5 mm long; bracteoles 2; calyx 10–12.2 mm long, the tube 8–9.5 mm long, cylindric, purple, sparsely black-strigose, the teeth 1.3–2.7 mm long, subulate; flowers 18–22 mm long, pink-purple; pods spreading to declined, stipitate, the stipe 1.5–4.5 mm long, the inflated body oblong-ellipsoid, 14–26 mm long, 7–14.5 mm thick, the valves papery and straw-colored, unilocular, glabrous; ovules 20–38. Mixed desert shrub and pinyon-juniper communities at 1330 to 1830 m in seleniferous soils in Emery, Grand, San Juan, and Wayne cos.; Colorado. The Eastwood milkvetch is closely allied to *A. preussii* It differs mainly in the shorter stems and spreading-descending, thin-textured pods; 6 (ii).

***Astragalus emoryanus* (Rydb.) Cory.** Emory Milkvetch. [*Hamosa emoryana* Rydb.]. Annual or winter annual, caulescent, 4–45 cm long, from a slender taproot; pubescence basifixed; stems prostrate; stipules 1.5–3.6 mm long, all distinct; leaves 1–4.5 cm long; leaflets 11–19, 2–10 mm long, 1–6 mm wide, oval-obovate to obcordate or oblanceolate, obtuse to retuse on all leaves, sparingly strigose on both sides or glabrate above; peduncles 2–6 cm long; racemes 2-to 10-flowered, the flowers spreading at anthesis, the axis 0.3–2.5 cm long in fruit; bracts 0.5–2 mm long; bracteoles 0; calyx 3.6–6 mm long, the tube 1.9–3.5 mm long, campanulate, strigose, the teeth 1.3–2.5 mm long; flowers 7.3–11 mm long, pink-purple; pods declined to ascending, sessile, narrowly oblong, curved, 0.8–2.2 cm long, 2.2–4.3 mm wide, trigonous, glabrous, bilocular; ovules 10–16. Pinyon-juniper community at 1700 m in Kane Co. (Cockscomb); Arizona, New Mexico, Texas, and Mexico. This is an obscure entity in Utah. It is very similar in most salient features with *A. nuttallianus*, from which it can be distinguished by the deciduous, straw-colored pods, merely strigose calyx teeth, retuse-obtuse leaflets on all leaves, and rounded keel-tip. This latter feature is shared with *A. nuttallianus* var. *micranthiformis*, but that entity is known to occur in Kane Co. only east of the Cockscomb; 1 (0).

***Astragalus ensiformis* M. E. Jones.** Pagumpa Milkvetch. [*A. ursinus* M. E. Jones, not A. Gray; *Hamosa ensiformis* (M. E. Jones) Rydb.; *A. ensiformis* var. *gracilior* Barneby; *A. minthorniae* var. *gracilior* (Barneby) Barneby.]. Perennial, caulescent, 8–45 cm tall, from a superficial to subterranean caudex; pubescence basifixed; stems decumbent to erect; stipules 4–10 mm long, all distinct; leaves 4–15.5 cm long; leaflets (5) 11–23, 6–24 mm long, 1.5–13.5 mm wide, ovate to oblong, obovate, or oblanceolate, obtuse to retuse, strigose (sometimes sparsely so) beneath, strigose to glabrous above; peduncles 2.5–13 cm long; racemes 12- to 30-flowered, the flowers ascending to declined at anthesis, the axis 3.5–13.5 cm long in fruit; bracts 2–6 mm long; pedicels 1–3.5 mm long; bracteoles 0–2; calyx 5.2–7.8 mm long, the tube 4.5–6.5 mm long; short-cylindric, pilosulose with black hairs, the teeth 1.2–2.5 mm long, subulate; flowers 13–17 mm long, purplish to pink-purple, the wing-tips pale to white; pods ascending to descending, sessile or substipitate, the body narrowly oblong, curved, 15–30 mm long, 4–6 mm thick, subterete (compressed laterally when pressed), bilocular, strigose to strigulose; ovules 24–36. Pinyon-juniper, sagebrush, and blackbrush-larrea communities at 1230 to 2350 m in Washington Co.; Mohave Co., Arizona. The materials included herein as portions of an expanded *A. ensiformis* have been treated as belonging to *A. ensiformis* sens. str. and to *A. ensiformis* or *A. minthorniae* as var. *gracilior*. The var. *gracilior* was named by Barneby (Calif. Acad. Sci. Proc. 25:158. 1944) as a variety of *A. ensiformis* on the basis of plants taken near Veyo. Later Barneby (Amer. Midl. Naturalist 55:493. 1956) transferred the variety to *A. minthorniae* (Rydb.) Jeps. The var. *gracilior* is supposed to differ fom *A. ensiformis* sens. str. by its erect (not short decumbent) stems, reflexed pedicels (not spreading-ascending), and by the sparingly long strigose (not shortly pilosulous) essentially pendulous (not ascending to erect) pods. With a rather substantial number of specimens now available the supposed diagnostic criteria fail as differential features. Stems are decumbent to ascending or erect, varying with each separate population. Peduncle position does not appear to be taxonomically important because of lack of correlation with other features. The position of the fruit is likewise not correlated with other characteristics. Pubescence size and shape forms a continuum. The final features, involving the pods, are tenuous at best and almost impossible to demonstrate at worst. Each sub-population varies, the whole consisting of apparent recombination types, with *A. ensiformis* sens. str. the extreme in one series and var. *gracilior*, the extreme in another. Thus, *A. ensiformis* is treated herein as consisting of a series of polymorphic populations, not readily separable into infraspecific taxa. The status of *A. minthorniae*, shorn of this taxon, is beyond the scope of this work; 18 (iv).

***Astragalus episcopus* S. Wats.** Bishop Milkvetch. [*Tragacantha episcopa* (S. Wats.) Kuntze; *Homalobus episcopus* (S. Wats.) Rydb.; *A. kaibensis* M. E. Jones; *Lonchophaca kaibensis* (M. E. Jones) Rydb.]. Perennial, caulescent, rush-like, 20–45 cm tall arising from a subterranean caudex; pubescence basifixed; stems erect or ascending; stipules 2–13 mm long, all distinct; leaves 2–10 cm long, most of them reduced to the rachis, some with leaflets 3–13 in number, the leaflets 1–15 mm long, 0.5–2 mm wide, linear to elliptic or oblong, acute to obtuse or emarginate, strigose on both sides; peduncles 6–23 cm long; racemes very loosely 6- to 30-flowered, the flowers ascending in anthesis, the axis 3–30 cm long in fruit; bracts 1.3–3 mm long; pedicels 1.5–3.5 mm long; bracteoles 0–2; calyx 4.1–7 mm long, the tube 3.4–5.2 (6) mm long, short cylindric, always much longer than broad, suffused purplish or very pale, white-strigose, the teeth 0.6–2.2 mm long, triangular to subulate; flowers 10–15.5 mm long, pale pink or whitish to pink-purple; pods pendulous, sessile or subsessile, the body oblong to lance-elliptic in outline, slightly curved to straight, 14–32 mm long, 4–8 mm wide, laterally compressed, glabrous to strigose, straw-colored or tinged or mottled purple, unilocular; ovules 16–26. Mixed desert shrub and pinyon-juniper communities often in clay or silty soils at 1270 to 1700 m in Emery, Garfield, Kane, and Wayne cos. (type from southern Utah); Arizona. The Bishop milkvetch closely simulates *A. lancearius* q.v., with which it is sympatric in Kane Co. and in Arizona. The calyx of *A. lancearius* is black-strigose, not or seldom suffused with purple, with the tube campanulate and as broad as long or only somewhat longer than broad, and the flowers are broader in proportion to length than in *A. episcopus*; 38 (xii).

***Astragalus eremiticus* Sheldon.** Hermit Milkvetch. [*A. arrectus* var. *eremiticus* (Sheldon) M. E. Jones]. Perennial, caulescent, 20–45 cm tall, from a branching commonly superficial caudex; pubescence basifixed; stems erect or ascending; stipules 3–11 mm long, 1.5–12 mm wide, ovate to oblong, elliptic, or narrowly oblong, obtuse toretuse, strigose beneath, glabrate to glabrous above; peduncles 2.5–15 cm long; racemes 10- to 26-flowered, the flowers ascending to declined at anthesis, the axis 5–17 cm long in fruit; bracts 1.5–4 mm long; pedicels 0.7–3.5 mm long; bracteoles 0–2; calyx 4.5–8.7 mm long, the tube 4–6.8 mm long, short-cylindric, strigose, the teeth 0.7–2 mm long, triangular to subulate; flowers 12–18 mm long, ochroleucous, pink-purple, or merely tinged purplish; pods erect, stipitate, the stipe 6–15 mm long, the body oblong to ellipsoid or obliquely ellipsoid, 12–27 mm long, 3.5–8 mm thick, trigonous, glabrous, bilocular; ovules 17–32. Juniper-pinyon, live oak, and sagebrush communities at 1130 to 1830 m in Kane (west of Cockscomb) and Washington cos.; Arizona, Nevada, and Idaho. Plants with inflated and proportionately shorter pod bodies simulate the rare *A. ampullarius* which occupies clay soils at lower elevations; 13 (i).

***Astragalus eucosmus* B. L. Robins.** Elegant Milkvetch. [*A. oroboides* var. *americanus* A. Gray, not *A. americanus* (Hook.) M. E. Jones; *Phaca elegans* Hook.; *A. elegans* (Hook.) Sheldon, not Bunge; *Atelophragma elegans* (Hook.) Rydb.]. Perennial, caulescent, 10–40 cm long, from a branching caudex; pubescence basifixed; stems erect to ascending; stipules 1.5–6 mm long, at least some of the lower ones usually connate-sheathing; leaves 2–10 cm long; leaflets 9–15, 10–22 mm long, 4–7 mm broad, obtuse, strigose beneath, glabrous or glabrate above; peduncles 5–18 cm long; racemes 7- to 25-flowered, the flowers declined at anthesis, the axis 3.5–15 cm long in fruit; bracts 1–3.5 mm long; pedicels 0.5–3 mm long; bracteoles usually 0; calyx 3.3–5.4 mm long, the tube 2.5–3.5 mm long, campanulate, strigulose, the teeth 0.9–1.6 mm long, subulate; flowers 6–8 mm long, purple or whitish; pods spreading to deflexed, sessile or subsessile, 8–12 mm long, 2.5–5 mm thick; laterally compressed, pilose, semibilocular; ovules 4–8. Woods, rare, north slope of Uinta Mountains, Summit Co., Utah; Alaska east to Nova Scotia and south to Colorado and Maine; 1 (0).

***Astragalus eurekensis* M. E. Jones.** Eureka Milkvetch. [*Xylophacos eurekensis* (M. E. Jones) Rydb.]. Perennial, acaulescent, 2–15 cm tall, the caudex branches obscured by persistent leaf bases; pubescence basifixed; stipules 3–11 mm long, all distinct; leaves 2–15 cm long; leaflets (3) 5–19, 3–35 mm long, 2–8 mm wide, elliptic to oblong, acute, gray or silvery strigose on both surfaces; peduncles 1–13 cm long, pilose; racemes 3- to 7-flowered, the flowers ascending at anthesis, the axis 0.2–2 cm long in fruit; bracts 4–8 mm long; pedicels 1.2–3 mm long; calyx 10.5–15.5 mm long, the tube 8.5–10.5 mm long, cylindric, pilose-villous, the teeth 2.5–5.7 mm long, subulate; flowers 22–27 mm long, ochroleucous, faintly to strongly suffused with purple or rarely pink-purple; pods ascending, sessile, obliquely lance-ovoid, 15–40 mm long, 5–9 mm thick, villous-hirsute, unilocular; ovules 26–36. Sagebrush, pinyon-juniper, and mountain brush communities at 1370 to 2135 m in Beaver, Garfield, Iron, Juab, Millard, Sanpete, Sevier, Tooele, Utah, and Wasatch cos.; endemic. When, as rarely, the flower color is bright pink-purple this entity, lacking fruit, is exceedingly difficult to separate from *A. newberryi* (q.v.); 51 (xiv).

Astragalus falcatus Lam. Russian Sickle Milkvetch. Perennial, caulescent, 40–90 cm tall, from a branching caudex; pubescence malpighian; stems ascending to erect, forming large clumps; stipules 2–12 mm long, at least some connate-sheathing; leaves 5–22 cm long; leaflets 19–37, 6–35 mm long, 1.5–10 mm wide oblong to elliptic or oblanceolate, acute to apiculate, strigose below, glabrous above, green on both sides; peduncles 6–17 cm long; racemes 20- to 70-flowered, the flowers delined at anthesis, the axis 3–20 cm long in fruit; bracts 2–5 mm long; pedicels 2–5 mm long, recurved in fruit; bracteoles 2; calyx 3.6–4.7 mm long, the tube 3–3.5 mm long campanulate, strigose, the teeth 0.5–1.2 mm long, triangular; flower 9–11 mm long, greenish-white, sometimes suffused with purple; pods decurved, subsessile, curved-oblong, 13–23 mm long, 2.5–4.5 cm wide, triangular, strigulose, bilocular, ovules 12–14. Introduced soil stabilization plant, established in Juab Co., and to be expected elsewhere in Utah; southeastern Europe. This is a robust perennial capable of surviving in harsh, heavy soils in the mountain brush zone of the state; 2 (ii).

Astragalus flavus **Nutt. ex Torr & Gray.** Yellow Milkvetch. Perennial, caulescent, 5–30 cm tall, from a branching caudex; pubescence malpighian; stems decumbent to ascending or erect; stipules 2–10 mm long, all connate-sheathing; leaves 3–15 (18) cm long; leaflets (5) 9–21, 3–31 mm long, 0.5–6 mm wide, linear, narrowly oblong, or oblanceolate to ovate, obtuse to acute, silvery strigose (greenish) on both sides or glabrate to glabrous above; peduncles 3–23 cm long; racemes 6- to 30-flowered, the flowers ascending at anthesis, the axis 2–12 cm long in fruit; bracts 1.5–5 mm long; pedicels 0.7–1.2 mm long; bracteoles 0; calyx 5.5–9.5 mm long, the tube 3–5.2 mm long, campanulate, strigose to pilose, the teeth 2–6 mm long, subulate; flowers 9–17 mm long, yellow to ochroleucous, whitish, lilac, or pink-purple; pods erect, sessile, oblong, 7–13 mm long, 3.5–5 mm thick, straight, dorsiventrally compressed, strigose, unilocular; ovules 6–17. Three more or less distinctive varieties, all primary selenophytes, are present in Utah.

1. Calyx shaggy long villous, the teeth 3–6 mm long, equaling or longer than the tube; flowers pink-purple; plants of Emery, Grand, Wayne, and Garfield cos. .... *A. flavus* var. *argillosus*

— Calyx strigose to short villous, the teeth 2–3 (4) mm long, shorter than the tube; flowers yellow to white or tinged purplish, rarely pink-purple; plants of various distribution 2

2(1). Flowers whitish or yellowish, sometimes tinged with purple, rarely pink-purple; keel 6–8 mm long; plants from central and southern counties .... *A. flavus* var. *candicans*

— Flowers cream to yellow; keel 8–10 mm long; plants from east-central to northeastern Utah .... *A. flavus* var. *flavus*

Var. *argillosus* (M. E. Jones) Barneby. [*A. argillosus* Jones; *Cnemidophacos argillosus* (M. E. Jones) Rydb.] Mancos Shale, Summerville, Cedar Mountain, and Morrison formations, on saline clays and silts with salt desert shrubs at 1230 to 1600 m in Emery (type from Green River), Garfield, Grand, and Wayne cos.; endemic; 23 (vi).

Var. *candicans* A. Gray. [*A. confertiflorus* A. Gray, type from near St. George; *Cnemidophacos confertiflorus* (A. Gray) Rydb.]. Mancos and Tropic shales, Moenkopi, Chinle, and Kaiparowits formations and other saline clays and silts at 900 to 2130 m in Garfield, Kane, San Juan, and Washington cos.; Arizona and Nevada. The var. *candi-*

cans passes into var. *flavus* in central eastern Utah; 43 (vii).

Var. *flavus*. [*Cnemidophacos flavus* (Nutt.) Rydb.; *Tragacantha flaviflora* Kuntze; *A. confertiflorus* var. *flaviflorus* (Kuntze) M. E. Jones]. Mancos Shale, Chinle, Moenkopi, Duchesne River, Uinta, and other formations composed of saline silts and clays in salt desert shrub and pinyon-juniper communities at 1230 to 1730 m in Carbon, Daggett, Duchesne, Emery, Grand, San Juan, Sanpete, Sevier, and Uintah cos.; Arizona, New Mexico, Colorado, and Wyoming. Sheep poisoning attributable to var. *flavus* is known from the lower elevation portions of the Uinta Basin; 40 (xiii).

***Astragalus flexuosus* (Hook.) Don.** Perennial, caulescent, 10–60 cm tall, from a branching caudex; pubescence basifixed; stems decumbent or ascending; stipules 1–7 mm long, at east the lowermost connate-sheathing; leaves 1.5–9 cm long; leaflets (5) 9–25, 3–19 mm long, 1–8 mm wide, linear or oblong to oblanceolate or obovate, obtuse to truncate or retuse, strigose to glabrate beneath, usually glabrous above; peduncles 1.5–14 cm long; racemes 7- to 26-flowered, the flowers spreading at anthesis the axis 2.5–13 cm long in fruit; bracts 0.6–4.5 mm long; pedicels 0.7–3.5 mm long; bracteoles 0–2; calyx 3.3–5.8 mm long, the tube 2.4–4.3 mm long, campanulate, strigose, the teeth 0.5–1.7 mm long, subulate; flowers 7–11 mm long, pink-purple to dull purplish; pods descending to spreading, sessile or short-stipitate, the stipe 0.5–1.3 mm long, the body oblong to oblanceolate or elliptic in outline, 8–24 mm long, 2.7–4.8 mm thick, subterete or variously somewhat flattened, strigose to glabrous, unilocular; ovules 12–25. Two rather distinctive varieties are present, both confined to eastern Utah.

1. Calyx tube 2.4–2.7 mm long; pods sessile or nearly so; plants spreading-decumbent, in pinyon-juniper and mixed desert shrublands .... *A. flexuosus* var. *diehlii*

— Calyx tube 2.7–4.3 mm long; pods subsessile to shortly stipitate; plants of pinyon-juniper and mountain brush communities .... *A. flexuosus* var. *flexuosus*

Var. *diehlii* (M. E. Jones) Barneby. [*A. diehlii* M. E. Jones; *Phisophaca diehlii* (M. E. Jones) Rydb.]. Salt desert shrub and pinyon-juniper communities at 1370 to 1670 m in Carbon, Emery, Grand, and Uintah cos.; Colorado; 12 (vii).

Var. *flexuosus*. [*Phaca flexuosa* Hook.; *Homalobus flexuosus* (Hook.) Rydb.; *Pisophaca flexuosa* (Hook.) Rydb.]. Pinyon-juniper and mountain brush communities at 1675 to 2135 m in Grand and San Juan cos.; British Columbia east to Ontario and south to New Mexico, Nebraska, and Minnesota; 2 (0).

***Astragalus fucatus* Barneby.** Hopi Milkvetch. [*A. subcinereus* sensu M. E. Jones, not Gray, q.v.]. Perennial, caulescent, 7–45 cm tall, from a subterranean to superficial caudex; pubescence basifixed; stems ascending to erect or sprawling; stipules 1–5.5 mm long, the lowest connate-sheathing; leaves 2–12.5 cm long; leaflets 9–17, 3–20 (25) mm long, 0.5–2.5 mm wide, obtuse to retuse, strigose beneath, glabrous above; peduncles 1–6.5 cm long; racemes 9- to 22-flowered, the flowers ascending to declined at anthesis, the axis 2–11.5 cm long in fruit; bracts 0.8–2 mm long; pedicels 0.7–3.5 mm long; bracteoles 0; calyx 3.3–5.4 mm long, the tube 2.3–3.3 mm long, campanulate, strigose, the teeth 0.8–2.2 mm long; flowers 6.4–8.7 mm long, pink-purple; pods spreading to declined, sessile, bladdery-inflated, ovoid, ellipsoid or subglobose, 17–32 mm long, 12–20 mm wide (when pressed), mottled, strigose, unilocular; ovules 21–32. Mixed desert shrub communities, usually in sandy soil, at 1330 to 1830 m in Garfield and San Juan cos.; Colorado, New Mexico, and Arizona; 18 (iv).

***Astragalus geyeri* A. Gray.** Geyer Milkvetch. [*Phaca annua* Geyer, not *A. annuus* DC.]. Annual (rarely biennial), caulescent, 6–27 cm long, from a slender taproot; pubescence basifixed; stems prostrate to ascending or erect; stipules 1.5–4 mm long, all distinct; leaves 2–10.5 cm long; leaflets 3–13, 3–17 mm long, 1–5.2 mm wide, linear to oblong or narrowly elliptic, obtuse to retuse, strigose beneath and strigose to glabrous above; peduncles 0.6–1.5 cm long; racemes 2- to 8-flowered, the flowers ascending at anthesis, the axis 0.8–1.5 cm long in fruit; bracts 0.7–2 mm long; pedicels 0.6–1.5 mm long; bracteoles 0–1; calyx 2.7–3.8 mm long, the tube 1.6–2.4 mm long, campanulate, strigose, the teeth 0.6–1.5 mm long; flowers 5–7.6 mm long, pale, suffused with purple, or pink-purple; pods spreading to declined, bladdery-inflated, obliquely ovoid, 15–24 mm long, 6–12 mm wide (when pressed), strigose, unilocular; ovules 7–18. Sandy soil in mixed desert shrub communities at 1370 to 1830 m in Beaver, Daggett, Duchesne, Emery, Garfield, Grand, Juab, Millard, Salt Lake, Tooele, Uintah, and Wayne cos.; Oregon east to Wyoming and south to California, Nevada, and Colorado. Plants grown from seed in a greenhouse produced mature fruit and seeds in 58 days; 32 (iv).

***Astragalus gilviflorus* Sheldon.** Plains Orophaca. [*A. triphyllus* Pursh, not Pallas; *Tragacantha triphylla* (Pursh) Kuntze; *Orophaca triphylla* (Pursh) Britt; *Phaca caespitosa* Nutt., not *A. caespitosus* Pallas; *Phaca argophylla* Nutt., not *A. argophyllus* Nutt. ex Torr. & Gray.]. Perennial, acaulescent, 1.5–13 cm tall, from a branching caudex; pubescence malpighian; stems entirely obscured by stipules; stipules 6–18 mm long, connate-sheathing; leaves 1–13 cm long, palmately trifoliolate, the leaflets 7–20 mm long, 2–7 mm wide, spatulate to elliptic, acute to obtuse silvery strigose on both sides; peduncles obsolete; racemes capitate, 1- to 3-flowered, the flowers erect, the axis very short in fruit; bracts 4.5–7.6 mm long, tridentate; pedicels 0–1.6 mm long; bracteoles 0; calyx 9.3–18 mm long, the tube 10–14 mm long, cylindric, loosely villous, the teeth 1.6–4 mm long; flowers 17–28 mm long, whitish to ochroleucous; pods erect, sessile, ovoid-ellipsoid, 6–10 mm long, 2.5–5 mm thick, densely hairy, unilocular. Sagebrush community at about 2130 m in Summit Co.; Alberta east to Ontario and south to Wyoming and Nebraska; 1 (0).

***Astragalus hallii* A. Gray.** Hall Milkvetch. [*A. fallax* S. Wats.; *A. familicus* Sheldon, not *A. fallax* Fischer; *A. gracilentus* var. fallax (S. Wats.) M. E. Jones; *Pisophaca familica* (Sheldon) Rydb.]. Perennial, caulescent, 12–50 cm tall, from a subterranean caudex; pubescence basifixed; stems decumbent to ascending or erect; stipules 1–7 mm long, at least the lowermost connate-sheathing; leaves 2–9 cm long; leaflets 11–23, 2–11 mm long, 1–7 mm wide, obovate to oblanceolate or elliptic, retuse to truncate or obtuse, strigulose beneath, sparingly hairy or glabrous above; peduncles 3–9.5 cm long; racemes 9- to 25-flowered, the flowers spreading-declined at anthesis, the axis 1–7 cm long in fruit; bracts 1.5–5 mm long; pedicels 1.2–4 mm long; bracteoles 0–2; calyx 6–7 mm long, the tube 5.2–6.2 mm long, short-cylindric, villosulous, the teeth 0.7–1.2 mm long, triangular; flowers 12.8–15 mm long, pink-purple; pods spreading to declined, short-stipitate, the stipe 1.5–3.5 mm long, the inflated body cylindroid to obliquely ovoid-ellipsoid, 19–27 mm long, 8–12 mm thick, strigulose, unilocular; ovules 20–37. Pinyon-juniper and mountain brush communities at 1600 to 2130 m in Garfield (?) and Kane cos.; Arizona and New Mexico. Our plants belong to **var. *fallax* (S. Wats.) Barneby.** They seem not to differ in any significant way from those of the Flagstaff Plateau in north-central Arizona; 3 (i).

***Astragalus hamiltonii* C. L. Porter.** Hamilton Milkvetch. Perennial, caulescent, 25–60 cm long, from a shallowly subterranean caudex; pubescence basifixed; stems erect; stipules 1.5–9.5 mm long, all distinct or rarely some shortly connate-sheathing; leaves 3–8 cm long, the uppermost (and sometimes the lowermost) simple, the others with leaflets 3–7, 10–47 mm long, 2–7 mm wide, elliptic to narrowly oblanceolate, obtuse to retuse, strigose on both sides, the terminal leaflet continuous with the rachis; peduncles 2.5–15.5 cm long; racemes 7- to 30-flowered, the flowers spreading-declined at anthesis, the axis 2–11 cm long in fruit; bracts 1–2.5 mm long;

pedicels 1.2–3 mm long; bracteoles 0–2; calyx 8.2–11 mm long, light brown, the tube 6.5–9.2 mm long, cylindric, gibbous, strigose, the teeth 1.7–2.6 mm long, subulate; flowers 20–24 mm long, ochroleucous, concolorous; pods pendulous, stipitate, the stipe 9–12 mm long, the body ellipsoid, 25–35 mm long, 4–7.5 mm thick, dorsiventrally compressed, the valves often brownish, strigose, unilocular; ovules 16–22. Duchesne River and Wasatch formations at 1600 to 1770 m in the juniper-pinyon community of western Uintah Co.; endemic. This is a mirrored-image cogener of *A. lonchocarpus* (q.v.), which is not known from the Uinta Basin; 8 (iii).

Astragalus harrisonii **Barneby.** Harrison Milkvetch. Perennial, caulescent, rush-like, 40–70 cm tall, from a subterranean caudex; pubescence basifixed; stems diffusely interbranched, in clumps to 1 m wide or more; stipules 1–5 mm long, all distinct; leaves 1.5–6.5 cm long, the uppermost simple, with the terminal leaflet expanded and confluent with the rachis, the others with leaflets 3–9, 2–11 mm long, 0.5–1.5 mm wide, linear-elliptic, acute, strigose on both sides; peduncles 6–19 cm long; racemes loosely 3- to 15-flowered, the flowers ascending at anthesis, the axis 5–40 cm long in fruit; bracts 0.5–1.1 mm long; pedicels 1.5–5.5 mm long; calyx 2.7–4.6 mm long, the tube 1.5–3.7 mm long, campanulate, strigose, the teeth 0.5–1.9 mm long, triangular; flowers 9–10.5 mm long, pink-purple; pods pendulous, stipitate, the stipe 3–4 mm long, the body narrowly ellipsoid, straight or curved, 17–28 mm long, dorsiventrally compressed, strigose to glabrous, unilocular; ovules 10–12. Pinyon-juniper community at 1650 m on Navajo Sandstone, Capitol Reef National Park, Wayne Co.; endemic. The Harrison milkvetch is a near cogener of *A. nidularius* (q.v.); 7 (iii).

Astragalus henrimontanensis **Welsh.** nom. nov. based on *Astragalus stocksii* Welsh Great Basin Nat. 34:307. 1974, not *A. stocksii* Benth. ex Bunge Astragal. Geront. 1:6. 1868. Dana Milkvetch. Perennial, acaulescent, 4–15 cm tall, from a branching caudex, the branches clothed with coarse, persistent leaf bases; pubescence basifixed; stipules 3–8 mm long, all distinct; leaves 2.7–12.5 cm long; leaflets 7–17, 3–13 mm long, 1.5–6 mm wide elliptic to oblanceolate, mucronate, acute to obtuse to truncate, strigose on both sides; peduncles 1.1–8 cm long; racemes 2- to 11-flowered, the flowers ascending at anthesis, the axis 0.3–2.2 cm long in fruit; bracts 1.8–5.5 mm long; pedicels 1.3–2.5 mm long; bracteoles 0–2; calyx 10.2–15 mm long, the tube 8.2–11.5 mm long, cylindric, strigulose, the teeth 1.9–3.5 mm long, subulate; flowers 15–23 mm long, ochroleucous, the wings and keel purple-tipped; pods ascending, sessile, lance-ovoid, slightly incurved, 22–35 mm long, 5–11 mm thick, somewhat dorsiventrally compressed, strigose, unilocular. Ponderosa pine, pinyon-juniper, and sagebrush communities at about 2430 m in the Henry Mountains, Garfield Co.; endemic. The Dana Milkvetch was named to honor Dana L. Stocks, late chairman of the Department of Botany at Brigham Young University. The species combines features of *A. argophyllus* var. *panguicensis*, as to pod shape and pubescence, and of *A. eurekensis*, as to habit and flower color; 11 (iv).

Astragalus humistratus **A. Gray.** Groundcover Milkvetch. [*Batiodophaca humivagans* Rydb.]. Perennial, caulescent, 7–80 cm long, radiating from a caudex; pubescence malpighian; stems prostrate; stipules 2–9 mm long, 0.5–6 mm wide, elliptic to oblong or oblanceolate, acute, strigose on both sides or glabrate above; peduncles 2–9 cm long; racemes 3- to 20-flowered, the flowers ascending at anthesis, the axis 1–12 cm long in fruit; bracts 1.5–7 mm long; pedicels 0.4–2.2 mm long; bracteoles 0–2; calyx 4.5–8.8 mm long, the tube 2.4–4.1 mm long, campanulate, strigose, the teeth 1.4–5 mm long; flowers 7–11.5 mm long, greenish to ochroleucous, often suffused or veined purplish, or pink-purple; pods ascending to spreading, obliquely ovoid or oblong-ellipsoid, 6–14 mm long, 3.5–5.7 mm wide, variously compressed, strigose, unilocular. Mountain brush, cool desert shrub, pinyon-juniper, and ponderosa pine communities at 1600 to 2430 m in Beaver, Garfield, Iron, Kane, and Washington cos.; Nevada, Arizona, and New Mexico. Our material belongs to var. **humivagans** (Rydb.) Barneby; 34 (xi).

Astragalus iodanthus S. Wats. Humboldt River Milkvetch. [*Tragacantha iodantha* (S. Wats.) Kuntze; *Xylophacos iodantha* (S. Wats.) Rydb.; *A. iodanthus* var. *diaphanoides* Barneby.]. Perennial, caulescent, 8–35 cm long, from a branching caudex; pubescence basifixed; stems prostrate to decumbent; stipules 2–6 mm long, all distinct; leaves 2–8 cm long; leaflets 7–21, 3–18 mm long, 2–12 mm wide, obovate to oblong or oblanceolate to elliptic, truncate to retuse, obtuse or mucronate, sparingly strigose to glabrous on both sides; peduncles 1–4.5 cm long, shorter than the leaf; racemes 7- to 17-flowered, the flowers ascending to spreading at anthesis, the axis 0.5–4.5 cm long in fruit; bracts 1–3 mm long; pedicels 0.3–2 mm long; bracteoles 2; calyx 5–8 mm long, the tube 3.4–5 mm long, short-cylindric, strigose, the teeth 1.3–3 mm long; flowers 12–15.5 mm long, pink-purple to pale; pods ascending to declined, sessile, the body curved through a half-circle, 20–40 mm long, 5–8 mm thick, dorsiventrally or trigonously compressed, obliquely lanceolate, unilocular or semibilocular, strigose; ovules 14–30. Juniper-sagebrush community at about 1670 m in Box Elder Co.; Oregon, California, and Nevada; 1 (0).

Astragalus iselyi Welsh. Isely Milkvetch. Perennial, caulescent, 8–25 cm tall, from a branching caudex; pubescence basifixed; stems ascending to erect; stipules 3–9 mm long, all distinct; leaves 3.2–8.5 cm long; leaflets (3) 5–13, 7–23 (37) mm long, 3–9 (16) mm wide, elliptic to rhombic, acute to mucronate, sparsely strigose to glabrate on both sides; peduncles 1.7–10 cm long; racemes 7- to 20-flowered, the flowers spreading at anthesis, the axis 1–3 cm long in fruit; bracts 2–4.5 mm long; pedicels 0.8–2.5 mm long; bracteoles 0; calyx 6.7–10 mm long, the tube 5.5–6.3 mm long, cylindric, strigulose, the teeth 1.8–3.1 mm long, subulate; flowers 17–18 mm long, ochroleucous, concolorous; pods spreading-declined, sessile or subsessile, inflated, subcylindric, 25–38 mm long, 10–15 mm thick, strigose, leathery, unilocular; ovules 38–44. Morrison and Paradox formations in pinyon-juniper and salt desert shrub communities at 1530 to 1830 m on western foothills of the LaSal Mountains in Grand and San Juan cos.; endemic. The Isely milkvetch is closely allied to *A. sabulosus* (q.v.). Both are obligate selenophytes of gypsiferous clays and silts of the Grand River Valley; 7 (iii).

Astragalus jejunus S. Wats. Starveling Milkvetch. [*Tragacantha jejuna* (S. Wats.) Kuntze; *Phaca jejuna* (S. Wats.) Rydb.]. Perennial, acaulescent, 1–4 cm tall, from a much-branched caudex; pubescence basifixed; stems obsolete, obscured by stipules and leaf bases; stipules 1.5–3 mm long, all connate-sheathing; leaves 1–4 cm long; leaflets 9–15, 1–5 mm long, 0.5–1 mm wide, linear to narrowly elliptic, obtuse to acute, involute, strigose on both sides; peduncles 0.5–3.5 cm long; racemes 3- to 7-flowered, the flowers spreading at anthesis, the axis 0.2–1 cm long in fruit; bracts 1–1.5 mm long; pedicels 1–2.5 mm long, very slender; bracteoles 0; calyx 2.3–3 mm long, the tube 1.5–2 mm long, campanulate, strigose, the teeth 0.5–1 mm long subulate; flowers 5–6.5 mm long, pink-purple; pods spreading, sessile, bladdery-inflated, subglobose, 10–17 mm long, 7–11 mm thick, mottled, strigose, unilocular; ovules 10–14. Sagebrush and sagebrush-juniper communities, often on windswept ridgetops at 1830 to 2300 m in Rich Co.; southwestern Wyoming and east-central Nevada. This tiny plant has as its nearest congener *A. limnocharis* (q.v.), a plant of higher elevations in central southern Utah; 2 (0).

Astragalus kentrophyta A. Gray. Kentrophyta. Perennial, caulescent, mat-forming to erect, 5–45 cm long, from a caudex and stolon-like creeping stems; pubescence basifixed or malpighian; stems prostrate to erect, compact to elongate; stipules 1.5–5 mm long, at least some connate-sheathing; leaves 0.4–2.6 cm long; leaflets 3–9, 3–13 mm long, 0.5–1.5 mm wide, linear to narrowly elliptic or lanceolate, all continuous with the rachis and spinulose-tipped, strigose on both sides; peduncles to 1.5 cm long; racemes 1- to 3-flowered, the flowers declined at anthesis, the axis to 0.5 cm long in fruit; bracts 0.8–3.5 mm long; pedicels 0.5–2 mm long; bracteoles 0; calyx 2.4–8.3

mm long, the tube 1.3–3.3 mm long, campanulate, strigose, the teeth 1.5–5 mm long, subulate; flowers 4.5–10 mm long, pink-purple or whitish, ochroleucous, or purplish-tinged; pods declined or spreading, sessile, elliptic to oblong or lance-acumuminate in outline, usually curved, 4–10 mm long, 1.3–4 mm wide, strigose, unilocular; ovules 2–8. Three rather distinctive varieties occur in Utah.

1. Pubescence entirely of basifixed hairs; plants prostrate, of barrens at high elevations .... *A. kentrophyta* var. *implexus*

— Pubescence mostly of malpighian hairs; plants prostrate to erect, of low to high elevations 2

2(1). Calyx 6–8.3 mm long, the teeth 3.4–5 mm long; pods 7–10 mm long; plants prostrate, of sandy sites in canyons of the Colorado .... *A. kentrophyta* var. *coloradoensis*

— Calyx 3.4–5.5 mm long, the teeth 1.5–2.4 mm long; pods 4–7 mm long; plants erect or prostrate, usually of clay or silty soils at low to higher elevations 3

3(2). Plants prostrate; pods 3–4.5 mm long, beakless or nearly so; known from Daggett Co. .... *A. kentrophyta* var. *jessiae*

— Plants erect or prostrate; pods 4–7 mm long, beaked; known from Duchesne Co., southward .... *A. kentrophyta* var. *elatus*

Var. *coloradoensis* M. E. Jones. Canyon Kentrophyta. [*A. montanus* var. *coloradoensis* (M. E. Jones) M. E. Jones; *Kentrophyta coloradoensis* (M. E. Jones) Rydb.]. Wash bottoms and rimrock in mixed desert shrub communities at 970 to 1630 m in Emery, Garfield, Kane, and Wayne cos.; Coconino Co., Arizona; a Colorado Plateau endemic; 15 (v).

Var. *elatus* Wats. Tall Kentrophyta. [*A. viridis* var. *impensus* Sheldon; *A. kentrophyta* var. *impensus* (Sheldon) M. E. Jones; *A. impensus* (Sheldon) Woot. & Standl.; *A. montanus* var. *impensus* (Sheldon) M. E. Jones; *A. tegetarius* var. *elatus* (S. Wats.) Barneby]. Juniper-pinyon, ponderosa pine, pine-spruce, mixed (often salt) desert shrub, and floodplain communities at 1530 to 2600 m in Beaver, Duchesne, Emery, Garfield, Iron, Kane, Piute, Sevier, and Wayne cos.; California, Nevada, Arizona, Colorado, and New Mexico. Both erect and prostrate phases are known, the presence of malpighian hairs is diagnostic; 45 (xvii).

Var. *implexus* (Canby) Barneby. Mountain Kentrophyta. [*A. tegetarius* var. *implexus* Canby; *A. tegetarius* S. Wats.; *Tragacantha tegetaria* (S. Wats.) Kuntze; *Homalobus tegetarius* (S. Wats.) Rydb.; *A. montanus* var. *tegetarius* (S. Wats.) M. E. Jones; *A. tegetarius* var. *rotundus* M. E. Jones, type from Loa; *A. kentrophyta* var. *rotundus* (M. E. Jones) M. E. Jones]. Ridgetops and breaks, commonly in barrens, at 2130 to 3500 m in Box Elder, Cache, Garfield, Iron, Juab, Kane, Salt Lake, Sanpete, Sevier, Summit, Tooele, and Utah cos.; Oregon to Montana and south to California, Nevada, and New Mexico; 48 (vii).

Var. *jessiae* (Peck) Barneby. Jessie Kentrophyta. [*A. jessiae* Peck]. White volcanic ash "barrens" at 1770 m in Daggett Co.; eastern Oregon, Idaho, and Wyoming; 1 (0).

***Astragalus lancearius* A. Gray.** Lancer Milkvetch. [*Homalobus lancearius* (A. Gray) Rydb.]. Perennial, caulescent, rush-like, 15–55 cm tall, arising from a subterranean caudex; pubescence basifixed; stems erect or ascending; stipules 2–7 mm long, all distinct; leaves 1.5–10.5 cm long, some or most of them reduced to the rachis some with leaflets 3–7 in number, 2–14 mm long, 0.5–1.5 mm wide, linear to oblong, acute to obtuse, strigose on both sides; peduncles 4–23 cm long; racemes very loosely 6- to 25-flowered, the flowers ascending at anthesis, the axis 3–19 (26) cm long in fruit; bracts 1–1.5 mm long; pedicels 1–3 mm long; bracteoles 0–2; calyx 3.5–5.2 mm long, the tube 2.8–4.2 mm long, campanulate, about as broad as long, campanulate, black-strigose, the teeth 0.5–1.2 mm long, triangular; flowers 8.8–11.5 mm long, pink-purple or merely tinged purplish; pods deflexed, sessile or subsessile, the body lance-oblong to oblong or lance-elliptic in outline, slightly curved or straight, 20–35 mm long, 5–9 mm wide, laterally compressed, glabrous to strigose, brown to straw-colored, unilocular; ovules 8–14. Mixed desert shrub and pinyon-juniper communities at 1270 to 1730 m in Kane and Washington cos.; Coconino and Mohave cos., Arizona; a Mohave-Virgin endemic. The lancer milkvetch is very similar to *A. episcopus* in most salient features (q.v.); 7 (i).

Astragalus lentiginosus **Douglas ex Hook.** Freckled Milkvetch. Perennial, caulescent, mostly 1.5–60 cm tall, from a caudex; pubescence basifixed; stipules 1.5–7 mm long or more, all distinct; leaves 2.4–15 cm long; leaflets 9–23, 2–23 mm long, 1–13 mm wide, elliptic to ovate or lanceolate, obtuse to rounded, emarginate, or acute, pubescent to glabrous on one or both sides; peduncles 1–14 cm long, sometimes more; racemes (5) 11- to 30-flowered, the flowers ascending to declined at anthesis, the axis 1–18 cm long in fruit; pedicels 1–4 mm long; bracts 1.5–6 mm long; bracteoles 0–2; calyx 3.5–11.6 mm long, the tube 3–9 mm long, cylindric to short-cylindric, strigose, the teeth 0.6–2.5 mm long, subulate or triangular; flowers 8.4–22 mm long, pink-purple, ochroleucous, whitish, or variously suffused with pink or purple; pods ascending to declined, sessile, variable in outline, either inflated and ovoid (12–26 mm long, 5–20 mm thick) or not inflated and oblong in outline (15–25 mm long, 3–7.5 mm thick), strigose or glabrous, mottled or not, leathery to membranous, bilocular; ovules 16–38. Some 10 varieties of freckled milkvetch are known to occur in Utah. The complex in Utah has been revised by Schoener (1975). A revision of the *Astragalus lentiginosus* complex for the state of Utah. (Unpublished MS thesis, BRY).

1. Flowers small, the keel 5.5–8.5 mm long 2
— Flowers larger, the keel 9–16 mm long or more 5

2(1). Raceme axis little elongating in fruit, not over 4 cm long 3
— Raceme axis much elongating in fruit, 4–15 cm long or more 4

3(2). Pods opaque, stiffly papery; rare plants of extreme west-central Utah .... *A. lentiginosus* var. *scorpionis*
— Pods transparent to translucent, thinly papery; plants locally common and rather widespread in western to central Utah .... *A. lentiginosus* var. *salinus*

4(2). Pods bladdery-inflated, the body globose or ovoid; plants of Washington Co. .... *A. lentiginosus* var. *fremontii*
— Pods not inflated, the body oblong to narrowly ellipsoid; plants of Iron (?) Co. .... *A. lentiginosus* var. *ursinus*

5(1). Raceme axis much elongating in fruit, usually more than 8 cm long 6
— Raceme axis not much elongating, seldom as much as 7 cm long in fruit 9

6(5). Flowers ochroleucous or faintly suffused with purple; pods diaphanous, glabrous; plants of Washington Co. .... *A. lentiginosus* var. *vitreus*
— Flowers ordinarily pink-purple to pink; pods usually opaque or strigose or both; distribution various 7

7(6). Pods bladdery-inflated; herbage cinereus, the stems canescent; plants known from the western slope of Beaverdam Mountains in Washington Co. .... *A. lentiginosus* var. *stramineus*

— Pods not or scarcely inflated; herbage greenish, the stems not or seldom canescent; plants of various distribution, but not as above 8

8(7). Flowers relatively large, the keel 10–15 mm long; plants from the Virgin and Colorado River canyons ..... *A. lentiginosus* var. *palans*

— Flowers smaller, the keel 8.5–10 mm long; plants rare and obscure, known only from "Bear Valley," Iron Co. ..... *A. lentiginosus* var. *ursinus*

9(5). Pods thinly papery, diaphanous; plants of eastern Kane Co. ..... *A. lentiginosus* var. *wahweapensis*

— Pods stiffly papery to leathery, opaque or nearly so; plants of various distribution 10

10(9). Leaflets 9–17; peduncles 1–5 cm long, shorter than the subtending leaves; flowers pale pink to whitish, or less commonly pink-purple; plants uncommon in northern Utah ..... *A. lentiginosus* var. *platyphyllidius*

— Leaflets 15–23; peduncles 2.5–8 cm long, mostly longer than the subtending leaves; plants variously distributed 11

11(10). Pods commonly strongly curved, with a long, lance-acuminate beak; plants common in Utah ..... *A. lentiginosus* var. *araneosus*

— Pods commonly little curved, with a broad triangular beak; plants uncommon in eastern Garfield and San Juan cos. ..... *A. lentiginosus* var. *albiflorus*

Var. *albiflorus* (A. Gray) Schoener. Bladder Milkvetch. [*A. diphysus* var. *albiflorus* A. Gray; *A. diphysus* A. Gray; *A. lentiginosus* var. *diphysus* (A. Gray) Jones; *Tragacantha diphysa* (A. Gray) Kuntze; *Cystium diphysum* (A. Gray) Rydb.] Pinyon-juniper and mixed desert shrub communities at 1470 to 1970 m in the Henry Mountains, Garfield Co., and in San Juan Co.; Colorado, Arizona, and New Mexico. The Utah materials are transitional to var. *araneosus* on the one hand and to var. *palans* on the other. The name is a misnomer, since the flowers are ordinarily a bright pink-purple; 3 (ii).

Var. *araneosus* (Sheldon) Barneby. Cobweb Milkvetch. [*A. araneosus* Sheldon, type from Frisco; *A. palans* var. *araneosus* (Sheldon) M. E. Jones; *Cystium araneosum* (Sheldon) Rydb.; *A. lentiginosus* var. *chartaceus* M. E. Jones, type from Ephraim]. Sagebrush, mixed desert shrub, pinyon-juniper, and less commonly, in mountain brush communities at 1270 to 2430 m in Box Elder, Beaver, Garfield, Iron, Juab, Kane, Millard, Piute, Sanpete, Sevier, Tooele, and Wayne cos.; Nevada. The var. *araneosus* is the common short-racemed milkvetch with bright pink-purple flowers in much of south-central to western Utah. It approaches var. *albiflorus* in some of its technical features. Acquisition of specimens connecting the ranges of vars. *araneosus* and *chartaceus* demonstrate complete intergradation of supposed diagnostic features and dictate that the two should be combined. Because the leaflet number appeared to be fewer than that acceptable for var. *araneosus*, the var. *chartaceous* was construed as to include var. *platyphyllidius* by Schoener (1975). That remainder of the materials treated previously as var. *platyphyllidius* is maintained as such, even though it is hardly uniform; 123 (xxxii).

Var. *fremontii* (A. Gray) S. Wats. Fremont Milkvetch. [*A. fremontii* A. Gray ex torr.; *A. coulteri* var. *fremontii* (A. Gray) M. E. Jones; *Cystium fremontii* (A. Gray) Rydb.] Braided stream gravels and slopes in creosote bush, Joshua tree, and pinyon-juniper communities at 670 to 1230 m in western Washington Co.; California and Nevada; 11 (ii).

Var. *palans* (M. E. Jones) M. E. Jones. Straggling Milkvetch. [*A. palans* M. E. Jones, type from Montezuma Canyon; *Tium* *palans* (M. E. Jones) Rydb.]. Salt desert shrub, blackbrush, juniper, pinyon-juniper, and mixed desert shrub communities at 1130 to 1900 m in Carbon, Emery, Grand, Kane, San Juan, Washington, and Wayne cos.; Colorado and Arizona. The straggling milkvetch is the common phase of *A. lentiginosus* in the canyons of the Colorado. It is distinctive in having oblong, usually curved pods, seldom more than 7 mm thick, and usually pale pink-purplish flowers; 88 (xxv).

Var. *platyphyllidius* (Rydb.) Barneby. Broad-leaved Milkvetch. [*Cystium platyphyllidium* Rydb.] Sagebrush, pinyon-juniper, and mountain brush communities at 17-0 to 2135 m in Daggett, Juab, Summit, and Tooele cos.; Oregon and California east to Wyoming and Colorado. The peduncles and commonly the fruiting racemes are surpassed by the subtending leaves. This feature, coupled with the leaflets which average fewer per leaf seem to distinguish var. *platyphyllidius* from most of var. *araneosus*. Flower color varies from whitish with keel-tip purple to pink-purple throughout; 9 (ii).

Var. *salinus* (Howell) Barneby. Salt Milkvetch. [*A. salinus* Howell; *Cystium salinum* (Howell) Rydb.]. Pinyon-juniper, mountain brush, and sagebrush communities at 1770 to 2430 m in Beaver, Iron and Summit cos.; California, Oregon, Nevada, Idaho, and Wyoming. There appear to be two main centers of distribution of this variety in Utah, one in Iron and Beaver cos., and one in the area of contact of the Uinta and Wasatch mountains in Summit Co. Schoener (1975) reported that salt milkvetch from Salt Lake, Wasatch and Morgan cos., presumably on the basis of plants collected by her, but there are no specimens in the herbarium at BRY from those localities. The tiny flowers and thin diaphanous pods are diagnostic; 12 (vii).

Var. *scorpionis* M. E. Jones. Scorpion Milkvetch. [*Cystium scorpionis* (Jones) Rydb.] Sagebrush community upwards to timberline at 2130 to 3350 m in western Juab Co.; Nevada. This rare, small-flowered plant differs from var. *salinus* mainly in its opaque, leathery pods; 1 (0).

Var. *stramineus* (Rydb.) Barneby. Straw Milkvetch. [*Cystium stramineum* Rydb., type from southern Utah]. Mixed warm desert shrub community at 900 to 1000 m on the western slope of the Beaverdam Mountains, Washington Co.; Arizona and Nevada. This is the only member of the species having moderate sized flowers known to occur in southwestern Washington Co.; it is a Beaverdam-Virgin endemic; 5 (0).

Var. *ursinus* (A. Gray) Barneby. Bear Milkvetch. [*A. ursinus* A. Gray, type from Bear Valley, south-central Utah]. Habitat and elevation and specific locality are unknown. Presumably, the material was collected in Bear Valley, northeastern Iron Co.; endemic. The variety has been compared with var. *palans* but the small flowers and presumed locality each preclude association with the straggling milkvetch. Possibly, the Bear milkvetch is extinct, but that seems unlikely when one considers the abundant material in the type collection. A catastrophe might account for its disappearance, however; 1 (0).

Var. *vitreus* Barneby. Glass Milkvetch. Creosote bush and mixed warm desert shrub community at 830 to 1430 m in central and eastern Washington Co.; Mohave and Coconino cos., Arizona. In its typical phase the flowers are very pale, either ochroleucous or white tinged with a faint pink to blue-purple. Southward and eastward the flower color becomes a bright pink-purple. The large, glassy, diaphanous pods are distinctive; 20 (iii).

Var. *wahweapensis* Welsh var. nov. *Astragalo lentiginoso* var. *araneoso* aemulans, differt leguminibus diaphanis et stramineis. Holotype: Utah, Kane Co., pinyon-juniper community at ca 1900 m in lower Kaiparowits Formation on Four Mile Bench, Welsh 12426, 8 May 1974 (BRY, nine isotypes). Additional materials; Utah, Kane Co., ca. 5 mi south of Cannonville, Welsh 5364, 6 May 1966; do, 4 mi south of Cannonville, Reveal et al 783, 4 June 1967; do, Wahweap Creek, Atwood 3474, 22 Mar. 1972; do, Four Mile Bench, Welsh 12413, 12 Apr. 1974; do, Smoky Mt., Cronquist 10022, 5 May 1965; do, Escalante road, Woodruff 1139, 12 June 1971; do, Four Mile Bench, Welsh & Murdock 12394, 12395, 17 May 1974; do, Four Mile Bench, Atwood 4064, 1 June 1972; do, Nipple Bench, Atwood & Allen 2920, 14 June 1971; do, Brigham Plains, Atwood & Allen 2791a, 13 June 1970; do, Four Mile Bench, Welsh 12446, 16 June 1974; do, Four Mile Bench, Welsh & Moore 13631, 29 June 1976 (all at BRY). The Wahweap milkvetch is an inhabitant of sandy soils mainly in pinyon-juniper and sagebrush communities at 1670 to 1900 m in the Paria, Wahweap, and Last Chance drainages west of the Kaiparowits Plateau proper. It is compared in the diagnosis to var. *araneosus* which surrounds the region, mainly at lower elevations, but shares features with var. *vitreus*, a low elevation plant to the south and west of the Wahweap centrum, which has more strongly graduated petals and usually larger and paler flowers; 16 (vii).

Astragalus limnocharis **Barneby.** Navajo Lake Milkvetch. Perennial, subacaulescent, 1–5 cm tall, arising from a branching caudex; pubescence basifixed; stems prostrate to erect; stipules 2–4 mm long, all connate-sheathing; leaves 1.5–7 cm long; leaflets (5) 7–13, 2–9 mm long, 1–2 mm wide, lanceolate to elliptic or oblong, obtuse, strigose beneath, long-ciliate on the involute margin, glabrous above; peduncles 2–5 cm long, reclining in fruit; racemes 2- to 10-flowered, the flowers spreading to declined at anthesis, the axis 0.2–0.5 cm long in fruit; bracts 1–3 mm long; pedicels 0.8–1.5 mm long; bracteoles 0; calyx 2.8–3.6 mm long, the tube 2–2.5 mm long, campanulate, strigose, the teeth 0.7–1.6 mm long, subulate; flowers 6.2–7.5 mm long, ochroleucous, concolorous; pods spreading, sessile, ovoid, bladdery-inflated, 9–18 mm long, 7–13 mm thick, mottled, strigose, unilocular; ovules 10–12. Lake shores and limestone breaks of Wasatch Formation at 2670 to 3400 m in Iron and Kane; endemic. This "lake beauty" has a principal locality on the beach at Navajo Lake where it is evidently dispersed by wave action. Plants can be found along the terraces below the high water line as the lake recedes. Evidently, the nearest allies of the Navajo Lake milkvetch is *A. jejunus* (q.v.), known in Utah only from Rich Co. and *A. montii* of the Wasatch Plateau; 10 (iii).

Astragalus loanus **Barneby.** Loa Milkvetch. [*A. newberryi* var. *wardianus* Barneby, type from east of Glenwood]. Perennial, acaulescent, 3–19 cm tall, the caudex branches clothed with a thatch of persistent leaf bases; pubescence malpighian; stipules 5–10 mm long, all distinct; leaves 2–18 cm long; leaflets (1) 3–11, 6–21 mm long, 2–12 mm wide, obovate to elliptic or lanceolate, obtuse to acute, densely strigose on both sides; peduncles 0.5–10 cm long; racemes 2- to 7-flowered, the flowers erect-ascending at anthesis, the axis 0.2–0.8 cm long in fruit; bracts 2.5–6 mm long; pedicels 1.2–1.8 mm long; bracteoles 0–2; calyx 10.7–18.5 mm long, the tube 8.5–14 mm long, cylindric, loosely strigulose, the teeth 1.7–4.5 mm long; flowers 20–28 mm long, ochroleucous or greenish-white often tinged faintly purplish, the keel-tip purple; pods ascending; sessile, inflated, ovoid, 17–30 (40?) mm long, 8–19 mm wide (when pressed), the valves red-purple to straw-colored, hirsute with lustrous long hairs, unilocular; ovules 28–38. Sagebrush and pinyon-juniper communities exclusively on igneous gravels at 1830 to 2570 m in Garfield, Piute, Sevier, and Wayne cos.; endemic. This remarkable species, known until recently from only four collections, apparently consists of two phases, separable inter alia by leaflet shape. The features are apparently not constant, and more specimens are required before the taxonomic status, if any, of the variants will be clarified; 14 (ix).

Astragalus lonchocarpus **Torr.** Great Rushy Milkvetch. [*Phaca macrocarpa* A. Gray; *Tragancantha lonchocarpa* (Torr.) Kuntze; *Homalobus macrocarpus* (A. Gray) Rydb.; *Lonchophaca macrocarpa* (A. Gray) Rydb.; *A. macer* A. Nels.; *L. macra* (A. Nels.) Rydb.]. Perennial, caulescent, 30–84 cm tall, from a shallowly subterranean caudex; pubescence basifixed; stems erect, often in dense clumps; stipules 1–9 mm long, all distinct; leaves 2–13 cm long, the uppermost and sometimes all simple, the lower with leaflets 3–9, 2–36 mm long, 0.5–4 mm wide, linear to narrowly oblanceolate, obtuse to acute, strigose on both sides or glabrous above; peduncles 6–24 cm long; racemes loosely 7- to 40-flowered, the flowers spreading-declined at anthesis, the axis 3.5–45 cm long in fruit; bracts 0.8–2.5 mm long; pedicels 1.3–4.5 mm long; bracteoles; calyx 5.8–10.3 mm long, usually brown, the tube 5–8 mm long, cylindric, gibbous, strigose, the teeth 0.6–2 mm long, subulate; flowers 13–20 mm long, ochroleucous to almost white, concolorous; pods pendulous, stipitate, the stipe 3–15 mm long, the body elliptic to oblong in outline, 22–50 mm long, 3.3–6.2 mm wide, dorsiventrally compressed, the valves often brownish, strigose, unilocular; ovules 12–26. Salt desert shrub, pinyon-juniper, floodplain, and seep communities at 1170 to 2530 m in Beaver, Carbon, Emery, Garfield, Grand, Iron, Juab, Kane, Millard, Piute, San Juan, Sevier, Tooele, and Wayne cos.; Colorado, New Mexico, Arizona, and Nevada; 85 (xxvii).

Astragalus lutosus **M. E. Jones.** Dragon Milkvetch. Perennial, short-caulescent, 2–10 cm tall, from a subterranean caudex; pubescence basifixed; stems prostrate to ascending, radiating; stipules 2–5 mm long, all distinct or some shortly connate-sheathing; leaves 1–5.5 cm long; leaflets 15–27, 1–9 mm long, 1–5 mm wide, obovate to elliptic, obtuse to retuse, gray-strigulose on both sides or glabrous above; peduncles 0.5–2 cm long; racemes 6- to 10-flowered, the flowers ascending-spreading at anthesis, the axis 0.3–1 cm long in fruit; bracts 1.5–2.5 mm long; pedicels 1.2–3 mm long; bracteoles 0; calyx 4.8–10.4 mm long, the tube 3.6–7.4 mm long, short-cylindric, strigulose, the teeth 1.2–3 mm long, subulate; flowers 9–17 mm long, white to ochroleucous, the keel-tip purplish; pods spreading to ascending, stipitate, the stipe (gynophore) 1–4.5 mm long, the body ovoid or ellipsoid bladdery-inflated, 15–37 mm long, 8–17 mm thick, strigose, unilocular. Bare places on white (Green River) shale ridges and talus slopes in mixed desert shrub community in southeastern Uintah Co. and in adjacent Rio Blanco Co., Colorado; a Uinta Basin Endemic. The Dragon milkvetch is one of the rarest of our species of milkvetches; 2 (0).

Astragalus malacoides **Barneby.** Kaiparowits Milkvetch. Perennial, caulescent, 7–25 cm tall, from a slightly subterranean caudex; pubescence basifixed; stems decumbent or prostrate to ascending; stipules 2–7 mm long, all distinct; leaves 4.5–14 cm long; leaflets 15–29, 3–25 mm long, 2–12 mm wide, obovate to oblong or elliptic, obtuse to emarginate, hirtellous beneath, glabrous above; peduncles 4–12 cm long; racemes 10- to 24-flowered, the flowers ascending-spreading at anthesis, the axis 1.2–10 cm long in fruit; bracts 3–5 mm long; pedicels 1–2.5 mm long; bracteoles 0–2; calyx 10–15 mm long, the tube 7–11 mm long, cylindric, hirsutulous, the teeth 2–6.2 mm long, linear-subulate; flowers 16–22 mm long, pink-purple; pods declined to ascending, short-stipitate, the stipe 2–3 mm long, the body oblong, curved, 25–40 mm long, 5–8 mm wide, laterally compressed, hirsutulous, bilocular; ovules 24–30. Straight Cliffs, Wahweap, Kaiparowits, and Moenkopi formations, usually in clay or silty soils, in juniper-pinyon and mixed desert shrub communities at 1600 to 2330 m in Garfield (Circle Cliffs and Tarantula Mesa) and Kane (Kaiparowits vicinity) cos.; endemic; 21 (iv.)

Astragalus marianus **(Rydb.) Barneby.** Sevier Milkvetch. [*Xylophacos marianus* Rydb., type from Marysvale]. Perennial, acaulescent or subacaulescent, 3–10 cm tall, from a branching caudex; pubescence basifixed; stems 0–6 cm long, the internodes mostly concealed by the stipules; stipules 2–7 mm long, all distinct; leaves 1.2–8.5 cm long; leaflets 7–17, 3–11 mm long, 1–4 mm broad, obovate to oblanceolate, obtuse to emarginate or acuminate to acute, strigose on both sides; peduncles 1–8 cm long; racemes 2- to 10-flowered, the flowers ascending at anthesis, the axis 0.2–3.5 cm long in fruit; bracts 2–4.5 mm long; pedicels 0.8–3 mm long; bracteoles 0–2; calyx 10–13.2 mm long, the tube 7.3–9.4 mm long, cylindric, pilosulous, the teeth 2–3.5 mm long, subulate; flowers 17–24 mm long, pink-purple, often pale; pods spreading-ascending, sessile or nearly so, 10–23 mm long, 7–12 mm thick, ovoid-acuminate, densely shaggy-hirsute, unilocular; ovules 27–36. Oak-sagebrush, mixed warm and cool desert shrub, pinyon-juniper, and aspen-white fir communities at 900 to 2430 m in Beaver, Garfield, Iron, Juab, Millard, Piute, Sevier, Washington and Wayne cos.; Nevada. The Sevier milkvetch resembles *A. argophyllus* var. *martinii* but the shaggy-hirsute pods and flowers that average smaller are diagnostic; 36 (xviii).

Astragalus megacarpus **(Nutt.) A. Gray.** Great Bladdery Milkvetch. [*Tragacantha megacarpa* (Nutt.) Kuntze; *A. megacarpus* var. *prodigus* Sheldon.]. Perennial, short-caulescent or subacaulescent, 3–15 (17) cm tall, arising from a caudex; pubescence basifixed; stems 1–5 cm long, in dense, leafy clumps, the internodes mostly obscured by stipules; stipules 2–7 mm long, all distinct; leaves 2–15 (17) cm long; leaflets 7–19, 3–19 mm long, 2–12 mm wide, obovate, ovate, elliptic, or suborbicular, obtuse to retuse and mucronate, strigose to glabrous beneath, glabrous above; peduncles 0.5–6 cm long, much shorter than the leaves; racemes 1- to 7-flowered, the flowers ascending in anthesis, the axis 0.2–2.5 cm long in fruit; bracts 2–5 mm long; pedicels 3.5–8 mm long; bracteoles 0–2; calyx 7–10.2 mm long, the tube 5.2–8.5 mm long, cylindric, strigose, the teeth 1.8–3.5 mm long; flowers 15–23 mm long, pink-purple; pods ascending to descending, stipitate, the stipe (gynophore) 2–4 mm long, the body bladdery-inflated, ellipsoid, 35–65 (70) mm long, 15–31 mm wide (when pressed), commonly mottled, strigose, unilocular; ovules 38–54. Commonly on clay soils, these often saline or calciferous, in salt desert shrub, sagebrush, oakbrush, pinyon-juniper, and ponderosa pine communities at 1650 to 2430 m in Carbon, Duchesne, Emery, Garfield, Iron, Juab, Kane, Millard, Sanpete, and Sevier cos.; Nevada, Wyoming, and Colorado. The great bladdery milkvetch is among our most distinctive species of *Astragalus*. A plant with its large pods declined on the ground around the base is a surprising sight. Our plants belong to **var. *parryi* A. Gray ex S. Wats.**, sens. str., but this variety apparently differs mainly in flower color (though our plants seem to have smaller calyces too) from var. *megacarpus*, sens. str.; 44 (xii).

Astragalus miser **Douglas ex Hook.** Weedy Milkvetch. Perennial, caulescent or short-caulescent, 3–35 cm tall, from a branching caudex; pubescence basifixed; stems decumbent to erect, 1–25 cm long or more; stipules 1.5–7 mm long, at least some connate-sheathing; leaves 1.5–2.0 cm long or more; leaflets 3–21, 3–35 mm long, 0.5–7 mm wide, linear to oblong, elliptic, or oval, acute to obtuse or emarginate, strigose beneath, glabrous or glabrate above; peduncles 2–14 cm long; racemes 3- to 20-flowered, the flowers spreading-declined at anthesis, the axis 1–10 cm long in fruit; calyx 2.1–5.2 mm long, the tube 1.9–2.9 mm long, campanulate, strigose, the teeth 0.5–2.5 mm long, subulate; flowers 5.9–10 mm long, pink-purple, ochroleucous, or whitish, often suffused or veined with purple; keel with an upturned usually purple beak; pods declined-pendulous, sessile or nearly so, narrowly oblong or oblanceolate in outline, 12–25 mm long, 2–4 mm wide, strigose, unilocular; ovules 8–19.

The weedy milkvetch is a widespread poisonous plant of middle and upper elevations in much of Utah. Both cattle and sheep are poisoned by this plant. Two rather tenuous varieties are known from Utah, one common and the other evidently rare.

1 Leaflets 3–11; flowers 6–8 mm long; pods narrowly oblong in outline; plants rare, scattered in northern Utah .... *A. miser* var. *tenuifolius*

— Leaflets mostly 11–21; flowers 8–11 mm long; pods oblanceolate in outline; plants common in Utah .... *A. miser* var. *oblongifolius*

Var. *oblongifolius* (Rydb.) Cronq. Rydberg Weedy Milkvetch. [*Homalobos oblongifolius* Rydb.; *A. hylophilus* var. *oblongifolius* (Rydb.) Macbr.; *A. decumbens* var. *oblongifolius* (Rydb.) Cronq.; *Homalobus humilis* Rydb., type from the Tushar

Mts.; *A. carltonii* Macbr., not *A. humilus* MB.] Aspen and mixed-aspen conifer, and coniferous woodlands, and in sagebrush, mountain brush, and alpine meadow communities at 1830 to 3500 m in all Utah counties except Box Elder, Davis, Millard, Morgan, San Juan, Tooele, Washington, and Weber cos., (and to be expected in some of them); Nevada, Arizona, Wyoming, and Colorado; 141 (xxvi).

Var. *tenuifolius* (Nutt.) Barneby. Garrett's Weedy Milkvetch. [*Homalobus tenuifolius* Nutt.; *H. paucijugus* Rydb.; *A. garrettii* Macbr., not *A. paucijugus* Schrenk.]. Sagebrush upwards to mountain summits at 1970 to 3050 m in Rich and Salt Lake (and likely in Summit) cos.; Idaho, Nevada, and Wyoming; 2 (0).

***Astragalus missouriensis* Nutt.** Missouri Milkvetch. Perennial, subacaulescent, 3–12 cm tall, from a caudex; pubescence malpighian; stems prostrate, to 8 cm long, the internodes often concealed by stipules; stipules 2–9 mm long, all distinct; leaves 1.5–12 cm long; leaflets 5–15, 3–15 mm long, 1–8 mm wide, elliptic to obovate, acute to mucronate or obtuse, strigose on both sides; peduncles 1.5–8 cm long; racemes 3- to 12-flowered, the flowers ascending at anthesis, the axis 0.4–3 cm long in fruit; bracts 2.5–8 mm long; pedicels 1–3.5 mm long; bracteoles 0–2; calyx 8.5–13 mm long, the tube 7–10 mm long, cylindric, strigose, the teeth 1.5–3 mm long, subulate; flowers 15–22 mm long, pink-purple, rarely white; pods ascending to descending, sessile, ellipsoid, 15–25 mm long, 7–9 mm thick, curved, dorsiventrally compressed, strigose, unilocular; ovules 35–55. Pinyon-juniper and sagebrush communities at 1600 to 2430 m in Grand and San Juan cos.; Colorado. Our materials are assignable to var. ***amphibolus* Barneby**; 2 (0).

***Astragalus moencoppensis* M. E. Jones.** Moenkopi Milkvetch. [*Cnemidophacos moencoppensis* (M. E. Jones) Rydb.]. Perennial, caulescent, 9–60 cm tall, from a branching caudex; pubescence basifixed; stems erect or ascending, commonly shorter than the longest peduncles; stipules 1.5–7 mm long, at least some connate-sheathing; leaves 4–16.5 cm long; leaflets 5–15, 2–23 mm long, 0.3–2 mm wide, filiform to linear or narrowly elliptic, acute to obtuse, the terminal often contiguous with the rachis, strigose below, glabrous on the involute upper surface; peduncles 4–25 cm long; racemes 6- to 34-flowered, the flowers ascending at anthesis, the axis 3–25 cm long in fruit; bracts 1.5–3.5 cm long; pedicels 0.3–2 mm long; bracteoles 0–1; calyx 5–7.5 mm long, the tube 3–4 mm long, campanulate, white-pilose, the teeth 1.8–3.5 mm long, lance-subulate; flowers 8–11 mm long, pink-purple; pods ascending-spreading, sessile, ovoid to ellipsoid, 6–7 mm long, 2.3–3.4 mm thick, strigulose, unilocular. Salt desert shrub, mixed desert shrub and pinyon-juniper communities at 1330 to 2130 m, usually in clay or silty soils, in Emery, Garfield, Grand, Kane, San Juan and Wayne cos.; Arizona. The Moenkopi milkvetch is a primary selenium indicator of distinctive mein and odor; 44 (xi).

***Astragalus mollissimus* Torr.** Woolly Locoweed. [*A. thompsonae* S. Wats.; *Tragacantha thompsonae* (S. Wats.) Kuntze; *A. bigelovii* var. *thompsonae* (S. Wats.) M. E. Jones; *A. syrticolus* Sheldon]. Perennial, acaulescent, 6–45 cm tall, from a caudex; pubescence basifixed; stems mostly obscured by stipules; stipules 4–13 mm long, all distinct; leaves 2–28 cm long; leaflets 15–35, 2–18 mm long, 1–14 mm wide, obovate to suborbicular or elliptic, obtuse to retuse oracute, densely wooly-tomentose on both sides; peduncles 2.5–24 cm long; racemes 7- to 20-flowered, the flowers ascending at anthesis, the axis 1.5–18 cm long in fruit; bracts 2.5–8 mm long; pedicels 0.5–3 mm long; bracteoles 0–2; calyx 11–15.5 mm long, the tube 7.7–23 mm long, cylindric, villous, the teeth 2–4.2 mm long, subulate; flowers 18–25 mm long, pink-purple; pods descending, sessile, ovoid, 11–23 mm long, 6–11 mm thick, curved, densely villous-tomentose, bilocular; ovules 28–38. Salt desert shrub, mixed desert shrub, grassland, and pinyon-juniper communities at 1130 to 2330 m in Carbon, Daggett, Duchesne, Emery, Garfield, Grand, Iron, Kane, Millard, San Juan, Tooele, Uintah, and Washington cos.; Nevada, Colorado, Arizona and New Mexico. The woolly locoweed is one of the earliest of the species of *Astragalus* to flower in Utah. It has been collected in anthesis as early as February in southern counties. The species as a whole is recognized as being poisonous. The plants are seldom abundant, except along roadsides, and this might account for the lack of reports of poisoning from this entity in Utah; 157 (xxxvi).

Astragalus montii **Welsh.** Heliotrope Milkvetch. Perennial, subacaulescent, 1–5 cm tall, arising from a branching caudex; pubescence basifixed; stems ascending to erect; stipules 2–4 mm long, all connate-sheathing; leaves 1.3–4.8 cm long; leaflets 5–13, 2–8 mm long, 1–2 mm wide, lanceolate to oblong or elliptic, strigose beneath, not ciliate on the involute margin, glabrous above; peduncles 0.8–4.5 cm long, reclining in fruit; racemes 2- to 8-flowered, the flowers ascending to spreading at anthesis, the axis 0.2–0.5 cm long in fruit; bracts 1–3 mm long; pedicels 0.8–1.5 mm long; bracteoles 0; calyx 3.3–4 mm long, the tube 2.2–2.5 mm long, campanulate, strigose, the teeth 0.6–1.5 mm long, triangular-subulate; flowers 7.2–8 mm long, pink-purple, the wingtips white; pods spreading, sessile, ovoid, bladdery-inflated, 11–18 mm long, 8–12 mm thick, mottled, strigose, unilocular; ovules 10. The heliotrope milkvetch is known only from Flagstaff Limestone at one locality at 3350 m on the Wasatch Plateau in Sanpete Co.; endemic. The species is a near congener of *A. limnocharis* from the Markagunt Plateau, differing inter alia in the pink-purple flowers which are larger and in the merely strigose (not long ciliate) leaf margins; 4 (i).

Astragalus monumentalis **Barneby.** Monument Milkvetch. Perennial, acaulescent or subacaulescent, 3–18 cm tall, from a branching caudex; pubescence basifixed or shortly malpighian; stems 1–6 cm long, ascending, the internodes commonly concealed by stipules; stipules 2–4 mm long, all distinct; leaves 1.5–8 (11) cm long; leaflets (5) 9–17 (21), 2–9 mm long, 1–4 mm broad, oval to obovate, elliptic, or oblanceolate, strigulose beneath, glabrous or glabrate above; peduncles 1–12 cm long; racemes 3- to 9-flowered, the flowers ascending at anthesis, the axis 0.5–7 cm long in fruit; bracts 1.5–5 mm long; pedicels 0.8–2.2 mm long; bracteoles 0; calyx 3.6–4.5 mm long, the tube 3.1–3.5 mm long, campanulate, strigose, purplish, the teeth 0.5–1 mm long; flowers 8–9 mm long, pink-purple; pods ascending, sessile or nearly so, narrowly oblong to lanceolate in outline, 12–21 mm long, 2.3–3 mm wide, straight or curved, triangular in cross-section, the dorsal suture sulcate, strigose, bilocular, often mottled. Rimrock and other slickrock sites in mixed desert shrub and pinyon-juniper communities at 1230 to 1870 m in Garfield and San Juan cos.; endemic. This is a mirrored-image cogener of *A. cottamii* (q.v.), differing in its smaller floral parts and overall flowers size and in the incipient malpighian pubescence; 19 (xii).

Astragalus musiniensis **M. E. Jones.** Ferron Milkvetch. [*Xylophacos musiniensis* (M. E. Jones) Rydb.; *A. musiniensis* var. *newberryoids* M. E. Jones, lectotype from the San Rafael Swell.] Perennial, acaulescent, 3–13 cm tall, from a caudex, the branches often clothed with a thatch of persistent leaf bases; pubescence basifixed or incipiently malpighian; stipules 3.5–10 mm long, all distinct; leaves 1.5–13 cm long; leaflets (1) 3–5, 5–35 mm long, 2–11 mm wide, elliptic to lanceolate, acute to obtuse, strigose on both surfaces; peduncles 0.5–7 cm long; racemes 1- to 6-flowered, the flowers erect-ascending at anthesis, the axis 0.2–1.4 cm long in fruit; bracts 1.6–4 mm long; pedicels 1.2–4 mm long; bracteoles 0; calyx 12–15.5 mm long, the tube 9.5–12.7 mm long, cylindric, strigose-pilose, the teeth 1.5–4 mm long; flowers 20–28 mm long, pink-purple; pods ascending, sessile, obliquely ovoid, 15–36 mm long, 8–17 mm thick, dorsiventrally compressed, hirsutulous to villous-hirsute, unilocular. Salt desert shrub, mixed desert shrub, and pinyon-juniper communities at 1430 to 2130 m in Carbon, Emery (type from 2 miles south of Ferron), Garfield, Grand, Kane, and Wayne cos.; endemic. The species was named by Marcus E. Jones for a mountain peak on the Wasatch Plateau many miles remote from the type locality; 30 (vii).

Astragalus nelsonianus **Barneby.** Nelson

Milkvetch. [*A. pectinatus* var. *platyphyllus* M. E. Jones.]. Perennial, caulescent, 10–30 cm tall, from a subterranean caudex; pubescence basifixed; stems decumbent to ascending or erect; stipules 4–13 mm long, at least some connate-sheathing; leaves 2.5–9 cm long; leaflets 3–13, 10–45 mm long, 2–5 mm wide, narrowly oblong, obtuse to apiculate, strigose on both surfaces, the terminal leaflet continuous with the rachis; peduncles 3–12 cm long; racemes 6- to 20-flowered, the flowers ascending at anthesis, the axis 2–12 cm long in fruit; bracts 2.5–7 mm long; pedicels 1.5–4 mm long; bracteoles 1; calyx 10–14.5 mm long, the tube 7–10.2 mm long, cylindric, strigose, the teeth 2–4.5 mm long; flowers 10–14 mm long, white, concolorous; pods deflexed, sessile, oblong-ellipsoid, 13–33 mm long, 6–12 mm wide, finally laterally compressed, glabrous or pubescent, unilocular; ovules 20–28. Saline soils in desert shrub communities at 2070 to 2100 m in Daggett Co.; Wyoming. The Nelson milkvetch differs from *A. pectinatus* Dougl. ex Don in much the same manner that *A. hamiltonii* differs from *A. lonchocarpus*. The leaves and leaflets of both *A. nelsonii* and *A. hamiltonii* are much broader than those of their counterparts; 3 (0).

***Astragalus newberryi* A. Gray.** Newberry Milkvetch. [*Xylophacos newberryi* (A. Gray) Rydb.; *A. newberryi* var. *castoreus* M. E. Jones, type from Beaverdam Mts.]. Perennial, acaulescent, 2–14 cm tall, from a caudex, the branches commonly clothed with a thatch of persistent leaf bases; pubescence basifixed; stipules 3–11 mm long, all distinct; leaves 1.5–14 cm long; leaflets 3–15, 3–20 mm long, 2–14 mm wide, obovate to elliptic, oblanceolate, or orbicular, acute to obtuse or retuse, villous-tomentulous on both surfaces; peduncles 0.5–11 cm long; racemes 2- to 8-flowered, ascending in flower, the axis 0.2–2.7 cm long in fruit; bracts 3.5–10 mm long; pedicels 1.4–5 mm long; bracteoles 0–2; calyx 11.5–20 mm long, the tube 8–17 mm long, cylindric, vilous, the teeth 1.9–6 mm long, subulate; flowers 20–32 mm long, pink-purple; pods ascending to spreading, sessile or subsessile, ovoid, curved, 18–23 mm long, 7–12 mm thick, densely villous-tomentose, unilocular; ovules 20–40. Salt desert shrub, mixed desert shrub, sagebrush, mountain brush, and pinyon-juniper communities at 830 to 2300 m in Beaver, Box Elder, Garfield, Iron, Juab, Kane, Millard, Sevier, Tooele, and Washington cos.; Oregon, Nevada, California, Arizona, and New Mexico; 65 (xix).

***Astragalus nidularius* Barneby.** Bird's-nest Milkvetch. Perennial, caulescent 15–51 cm tall, from a subterranean caudex; pubescence basifixed; stems ascending to erect, often branched; stipules 1–6 mm long, at least some connate-sheathing; leaves 1.5–7 cm long; leaflets 5–11, 2–20 mm long, 1.3–2 mm wide, linear to oblong, obtuse to emarginate or acute, the terminal leaflet of upper leaves sometimes continuous with the rachis, pubescent on both sides or glabrous above; peduncles 4–16 cm long; racemes (3) 8- to 33-flowered, the flowers ascending to declined at anthesis, the axis 1.5–28 cm long in fruit; bracts 1.2–2.2 mm long; pedicels 1.2–3 mm long; bracteoles 0–2; calyx 3.8–7 mm long, the tube 3.3–5.5 mm long, campanulate, strigose, the teeth 1.5–2.2 mm long, subulate; flowers 10.5–15 mm long, pink-purple; pods pendulous, stipitate, the stipe 3.5–6 mm long, the body narrowly oblong, 20–32 mm long, 3.5–4.5 mm thick, dorsiventrally compressed, strigose, unilocular; ovules 20–24. Pinyon-juniper and mixed desert shrub communities on Cutler, Moenkopi, and Navajo formations at 1370 to 1900 m in Garfield, San Juan, and Wayne cos.; endemic. The bird's-nest milkvetch is a close ally of *A. harrisonii* (q.v.), from which it is separated geographically and in technical morphological features; 13 (xii).

***Astragalus nuttallianus* Nutt.** Small-flowered Milkvetch. Annual or winter annual, caulescent, 2–35 cm long, from a taproot; pubescence basifixed; stems prostrate to decumbent or erect; stipules 1–5 mm long, all distinct; leaves 1–8.5 cm long; leaflets 7–19, 2–14 mm long, 1–6 mm wide obovate to elliptic or oblong, acute to rounded or retuse to emarginate, strigose to glabrous on both sides; peduncles 1–8 cm long; racemes 1- to 7-flowered, the flowers ascending to declined at anthesis, the axis 0.2–2 cm long in fruit; bracts 0.5–2.5 mm long; pedicels 0.4–1.6 mm long; bracteoles 0; calyx 3.2–5.4

mm long, the tube 1.9–2.8 mm long, campanulate, strigose, the teeth 1–2.2 mm long, subulate; flowers 4.1–7.6 mm long, pink-purple to whitish or faintly tinged with purplish; pods ascending to declined, sessile or subsessile, narrowly oblong, curved, 12–21 mm long, 1.9–3.3 mm wide, glabrous to strigose, bilocular or nearly so; ovules 12–18. There are two allopatric varieties of this annual milkvetch in Utah.

1. Leaflets 9–15; axis of raceme 0.5–2 cm long in fruit; keel tip blunt; plants of eastern Kane Co. and eastward in Utah .... *A. nuttallianus* var. *micranthiformis*

— Leaflets 7–11; axis of raceme 0.1–1 cm long in fruit; keel tip acute to subacute, usually beaked; plants from central Kane Co. west to Washington Co., and disjunctly north to Tooele Co. .... *A. nuttallianus* var. *imperfectus*

Var. *imperfectus* (Rydb.) Barneby. [*Hamosa imperfecta* Rydb.]. Creosote bush, warm desert shrub, and cool desert shrub communities at 670 to 1470 m in Kane and Washington and disjunctly in Tooele (Stansbury Island) cos.; Nevada, California, and Arizona; 23 (iv).

Var. *micranthiformis* Barneby. Blackbrush, mixed desert shrub, and pinyon-juniper communities at 1130 to 1670 m in Emery, Garfield, Grand, Kane, and San Juan cos.; Arizona, Colorado, and New Mexico; 13 (vii).

***Astragalus oophorus* S. Wats.** Egg Milkvetch. Perennial, caulescent, 15–30 cm tall, from a caudex; pubescence basifixed; stems decumbent to ascending, radiating from the caudex; stipules 1.5–7 mm long, all distinct; leaves 3–21 cm long; leaflets 9–25, 3–20 mm long, 2–11 mm wide, oval to obovate or orbicular, obtuse to retuse or mucronate, glabrous on both surfaces, often ciliate; peduncles 4–13 cm long; racemes 4- to 13-flowered, the flowers spreading at anthesis, the axis 1–8 cm long in fruit; bracts 1.5–5 mm long; pedicels 2–6 mm long; bracteoles 0–1; calyx 6–12 mm long, the tube 4–8.5 mm long, cylindric or short-cylindric, glabrous or sparingly strigose, the teeth 2–5 mm long, subulate; flowers 17–24 mm long, ochroleucous, concolorous, or pink-purple and with white wing-tips; pods spreading to pendulous, stipitate the stipe (gynophore) 3.5–12 mm long, the body bladdery-inflated, ellipsoid, 25–55 mm long, 10–30 mm wide (when pressed), glabrous, unilocular, often mottled; ovules 28–54. Two distinctive varieties are present in Utah.

1. Flowers pink-purple; calyx tube 7.8–9 mm long; stipe (gynophore) 10–12 mm long; plants of western Iron and Beaver cos. .... *A. oophorus* var. *lonchocalyx*

— Flowers ochroleucous; calyx tube 4–7 mm long; stipe (gynophore) 3.5–8.5 mm long; plants widespread .... *A. oophorus* var. *caulescens*

Var. *caulescens* (M. E. Jones) M. E. Jones. Pallid Egg Milkvetch. [*A. megacarpus* var. *caulescens* M. E. Jones, type from Loa Pass; *A. artipes* A. Gray; *Phaca artipes* (A. Gray) Rydb.; *A. oophorus* var. *artipes* (A. Gray) M. E. Jones]. Sagebrush, pinyon-juniper, and mountain brush communities at 1370 to 2430 m in Beaver, Garfield, Iron, Juab, Kane, Millard, Piute, Sanpete, Sevier, Tooele, Utah, and Washington cos.; Colorado, Arizona, and Nevada. Please compare this variety to *A. beckwithii* var. *beckwithii*; 66 (vi).

Var. *lonchocalyx* Barneby. Pink Egg Milkvetch. Pinyon-juniper, sagebrush, and mixed desert shrub communities at 1770 to 2300 m in western Iron and Beaver cos.; Lincoln Co., Nevada; a Great Basin endemic; 7 (iv).

***Astragalus pardalinus* (Rydb.) Barneby.** Panther Milkvetch. [*Phaca pardalina* Rydb.] Perennial (short-lived) or functionally annual, caulescent, 8–30 (35) cm tall; pubescence basifixed; stems decumbent to ascending, forming rounded clumps; stipules 2–5 mm long, all distinct or some shortly connate-sheathing; leaves 3–7 cm long; leaflets 11–17, 3–20 mm long, 1–5 mm wide, oblong to oblanceolate or obovate, truncate to retuse, mucronate, or acute, strigulose on both sides; peduncles 1–4 cm long; racemes 3- to 8-flowered, the flowers ascending at anthesis, the axis 1–4 cm long in fruit, bracts 1–3.5 mm long; pedicels 0.8–3.6 mm long; bracteoles 0–2; calyx 4.8–6.6 mm long, the tube 2.3–2.8 mm long, campanulate, villous, the teeth 2.3–2.8 mm long, subulate; flowers 6.3–8.2 mm long, pink-purple (soon fading yellowish); pods declined, sessile or nearly so, obliquely ovoid-ellipsoid, inflated, 13–21 mm long, 8–11 mm thick, straight or only slightly curved, villosulous with spreading-curved hairs, unilocular; ovules 20–28. Mixed desert shrub and pinyon-juniper communities usually in sandy soils at 1270 to 1600 m in Emery (type from Cedar Mt.), Garfield, and Wayne cos.; endemic. The panther milkvetch shares several salient features with the closely related but largely allopatric taxa *A. pubentissimus* and *A. sabulonum* (q.v.). From both of these, *A. pardalinus* differs in its straight or nearly straight pods, which bear 20–28 ovules (not 9–19). The main area of distribution of the panther milkvetch is on the sandy eastern foot of the San Rafael Swell which breaks abruptly to the canyons of the Green and Colorado rivers; 13 (vii).

***Astragalus pattersonii* A. Gray ex Brand.** Patterson Milkvetch. [*Tragacantha pattersonii* (A. Gray) Kuntze; *Phacopsis pattersonii* (A. Gray) Rydb.; *Rydbergiella pattersonii* (A. Gray) Fedde; *Jonesiella pattersonii* (A. Gray) Rydb.]. Perennial, caulescent, 20–45 (50) cm tall, from a branching caudex; stems decumbent to ascending or erect; stipules 3–8 mm long, all usually distinct; leaves 5–13 cm long; leaflets 7–15 or more, 6–38 mm long, 3–16 mm wide, elliptic to lanceolate, oblanceolate, or obovate, obtuse to acute, retuse, or mucronate, strigose to glabrous on both sides; peduncles 3–18 cm long; racemes 6-to 24-flowered, the flowers declined-nodding at anthesis, the axis 2–15 cm long in fruit; bracts 2–8 mm long; pedicels 1–4.5 mm long; bracteoles 2; calyx 8.8–14.2 mm long, the tube 6–8.8 mm long, cylindric, gibbous, pale tan or whitish, colored like the petals, thinly strigulose, the teeth 2.3–6.5 mm long, subulate; flowers 14–22 mm long, white, concolorous or the keel tip faintly purplish; pods erect, sessile, cylindric to ellipsoid or ovoid, 17–35 mm long, 6–10 mm thick, glabrous or puberulent, unilocular; ovules 22–38. Pinyon-juniper and mixed desert shrub communities at 1470 to 2300 m, disjunct in Utah, in Carbon, Garfield, Sevier, and Uintah cos.; Colorado and Arizona. The Patterson milkvetch is a primary selenium indicator, usually of clay and silty soils. The Arizona materials are known from the valley of Kanab Creek, and this plant might also occur in adjacent Kane Co. The Patterson milkvetch is a handsome and striking plant, which is similar in many ways with *A. praelongus* (q.v.), from which it differs in the whitish, concolorous calyces and petals, and in the erect pods; 11 (vi).

***Astragalus perianus* Barneby.** Rydberg Milkvetch. Perennial, short-caulescent, 1–6 cm tall, from a shallowly subterranean, branching caudex; pubescence basifixed; stems prostrate, 3–12 cm long; stipules 1–2.5 mm long, at least some connate-sheathing; leaves 1–3 cm long; leaflets 7–19, 1–5 mm long, 1–3 mm wide, oval to obovate, retuse, strigulose on both sides or glabrate above; peduncles 0.3–2.2 cm long; racemes 2- to 6-flowered, the flowers spreading at anthesis, the axis 0.2–0.8 cm long in fruit; bracts 0.8–1.2 mm long; pedicels 1.4–21.5 mm long; bracteoles 0; calyx 3.5–4.2 mm long, the tube 2.3–3 mm long, campanulate, pilosulous, purplish, the teeth 1–1.4 mm long, subulate; flowers 6.8–8.5 mm long, whitish, faintly suffused with pink or purple; pods ascending to declined, sessile, bladdery-inflated, ovoid, 10–23 mm long, 8–14 mm wide (when pressed), strigose, purple-mottled, unilocular; ovules 18–20. Tertiary igneous gravels, often on barrens, in alpine sites at 3050 to 3350 m in Garfield (Sevier Plateau) and Piute (Tushar Mts.) cos.; endemic. This beautiful low plant was first collected by P. A. Rydberg on 23 July 1905. It remained unnamed until its publication by Barneby (1964:973), and was not discovered a second time until 26 June 1975, some 70 years after its original collection. The Rydberg milkvetch most closely resembles *A. serpens* (q.v.), but its relationship purportedly lies elsewhere; 7 (iv).

Astragalus pinonis **M. E. Jones.** Pinyon Milkvetch. [*Pisophaca pinonis* (M. E. Jones) Rydb.]. Perennial, caulescent, 10–55 cm tall, from a shallowly subterranean caudex; pubescence basifixed; stems erect or reclining, commonly growing through sagebrush canopy; stipules 1.5–5 mm long, all distinct; leaves 2–11 cm long; leaflets 9–19, 2–18 mm long, 1–4 mm wide, linear to oblong, obtuse to retuse, strigose on both surfaces; peduncles 1.5–8 cm long; racemes 5- to 19-flowered, the flowers ascending-spreading at anthesis, the axis 2–7 cm long in fruit; bracts 1–2 mm long; pedicels 1–3 mm long; bracteoles 0–1; calyx 4.3–5.6 mm long, the tube 2.3–3.8 mm long, campanulate, strigose, the teeth 1–2 mm long, subulate; flowers 8.2–10.3 mm long, greenish to ochroleucous, suffused with purple; pods spreading-declined, subsessile, oblong-ellipsoid, straight to slightly curved, 20–35 mm long, 5.5–8.5 mm thick, terete or nearly so, strigose, unilocular; ovules 32–42. Sagebrush and sagebrush mixtures in pinyon-juniper woodlands at 1580 to 2275 m in Beaver and Juab cos.; Nevada; a Great Basin endemic. The pinyon milkvetch is obscure and apparently rare in Utah. The type was collected at Frisco, Beaver Co., where M. E. Jones found the plant in 1880 (on June 22). It grows up through low plants of sagebrush and is difficult to see. The plants resemble those of *A. convallarius*, but the thicker pods and jointed terminal leaflets of *A. pinonis* are diagnostic; 2 (0).

Astragalus platytropis **A. Gray.** Broad-keeled Milkvetch. [*Tragacantha platytropis* (A. Gray) Kuntze; *Phaca platytropis* (A. Gray) Rydb.; *Cystium platytrope* (A. Gray) Rydb.]. Perennial, acaulescent or nearly so, 2–7 cm tall, from a branching caudex, the branches often with a thatch of persistent leaf bases; pubescence basifixed; stems 0–2 cm long, prostrate-ascending or erect; stipules 1.5–5 mm long, at least some connate-sheathing; leaves 1–7 cm long; leaflets 5–15, 2–11 mm long, 1.5–7 mm wide, elliptic to obovate, oblong, or oval, acute to obtuse or retuse silvery-strigose on both sides; peduncles 1.5–6.5 cm long; racemes 2- to 9-flowered, the flowers ascending at anthesis, the axis 0.2–0.6 cm long in fruit; bracts 0.6–2 mm long; pedicels 0.7–1.9 mm long; bracteoles 0–2; calyx 3–5.4 mm long, the tube 2–3.4 mm long, campanulate, strigose, the teeth 0.2–2.1 mm long, subulate; flowers 7–9.5 mm long, pink-purple; pods ascending, sessile, bladdery-inflated, ovoid to subglobose, 15–33 mm long, 10–22 mm wide (when pressed), purple-mottled, strigulose, semibilocular; ovules 26–34. Ridge tops in shrub communities at 2400 to 3500 m in western Beaver and Tooele cos.; Nevada and California. This milkvetch is known in Utah only from the Mountain Home and Deep Creek ranges, where it occurs on limestone summits in crevices; 2 (i).

Astragalus praelongus **Sheldon.** Stinking Milkvetch. Perennial, caulescent, 10–90 cm tall, from a branching caudex; pubescence basifixed; stems erect or ascending, forming clumps; stipules 2.5–9 mm long, all distinct; leaves 3–22 cm long; leaflets 7–33, 3–50 mm long, 2–24 mm wide, obovate, elliptic, oblong, lanceolate, or oblanceolate, obtuse or retuse to acute, sparingly strigose beneath, glabrous above; peduncles 4–26 cm long; racemes 10- to 33-flowered, the flowers deflexed at anthesis, the axis 3–16 cm long in fruit; bracts 1–7 mm long; pedicels 1–7 mm long; bracteoles 2; calyx 5.8–14 mm long, the tube 4.4–7.5 mm long, cylindric, gibbous, glabrous, or thinly strigose, green or yellowish, usually differently colored than the petals, the teeth 0.3–6 mm long, subulate; flowers 15–24 mm long, ochroleucous, the keel often faintly purplish-tipped; pods erect to declined, sessile, subsessile, or stipitate, inflated, ellipsoid, ovoid, obovoid, or subglobose, 18–42 mm long, 15–25 mm thick, usually straight, glabrous or puberulent, subunilocular, leathery-woody; ovules 40–75. The stinking milkvetch is represented in Utah by three more or less distinctive varieties.

1. Pods long-stipitate, the stipe 4–8 mm long; plants of San Juan Co. .... *A. praelongus* var. *lonchopus*

— Pods sessile or short-stipitate, the stipe, when present, less than 3 mm long; plants seldom of San Juan Co. 2

2(1). Pods narrowly elliptic to oblong, 6–10 mm thick; plants of Beaver, Iron, Millard, and Sevier cos. eastward to east-central Utah .... *A. praelongus* var. *ellisiae*

— Pods broadly oblong to elliptis, 10–15 mm thick; plants of Garfield, Kane, Washington, and Wayne cos., and disjunctly in Sevier Co. .... *A. praelongus* var. *praelongus*

Var. *ellisiae* (Rydb.) Barneby in Turner. [*Jonesiella ellisiae* Rydb.]. Clay soil, commonly on Mancos Shale, Monekopi, and Chinle formations, but also on alluvial substrates containing selenium, at 1330 to 1970 m in Beaver, Carbon, Emery, Grand, Iron, Millard, northern San Juan, Sevier, and Wayne cos.; Colorado, New Mexico, and Texas. The Ellis stinking milkvetch passes by degree into var. *praelongus*. It seems clear, however, that most of the Great Basin populations are more closely allied with those of the San Rafael Swell region than they are with those of Washington Co. The relationship appears to have resulted from migration of plants of the *ellisiae* type through passes in the Wasatch Plateau rather than by a north-south exchange of typical phases; 54 (xviii).

Var. *lonchopus* Barneby. Clay, seleniferous soils of various formations, in blackbrush, mixed desert shrub, and pinyon-juniper communities at 1300 to 1925 m in southern San Juan Co.; Arizona; a Colorado Plateau endemic; 13 (iii).

Var. *praelongus* [*A. procerus* Gray, not Boiss. & Housskn.; *A. pattersonii* var. *praelongus* (Sheldon) M. E. Jones; *Phacopsis praelongus* (Sheldon) Rydb.; *Rydbergeilla praelonga* (Sheldon) Fedde & Sydow; *Jonesiella praelonga* (Sheldon) Rydb.]. Clay and silt of the Mancos Shale, Tropic Shale, Moenkopi, and Chinle formations, and other seleniferous soils, in salt desert shrub and pinyon-juniper communities at 770 to 2530 m in Garfield, Kane, Sevier, Washington, and Wayne cos.; Nevada, Arizona, and New Mexico. The type variety of stinking milkvetch demonstrates much variation. The most extreme phase occurs in Washington and portions of Kane cos., and has fistulous tall stems and greatly thickened pods. Still another from Washington Co. has pinkish-lavender flowers. Most of these plants are primary selenophytes, however, a small population from near the mouth of Zion Canyon lacked the characteristic odor of selenium and presumably was not seleniferous; 81 (xxv).

***Astragalus preussii* A. Gray.** Preuss Milkvetch. Perennial, caulescent, mostly 12–45 cm long, from a woody caudex; pubescence basifixed; stems erect or ascending, forming clumps; stipules 2–7 mm long, all distinct; leaves 3.5–13 cm long; leaflets 7–25, 1–28 mm long, 1–6 mm wide, obovate or obcordate to oblong, narrowly elliptic, lanceolate, or linear, emarginate to rounded, obtuse, or acute, glabrous; peduncles 2–15 cm long; racemes 3- to 22-flowered, the flowers ascending, the axis 1–20 cm long in fruit; bracts 1.5–4 mm long; pedicels 1–5.5 mm long; bracteoles 2; calyx 6.4–12.3 mm long, the tube 5.1–9.7 mm long, cylindric, thinly strigose, purple, the teeth 1.3–2.6 mm long, subulate; flowers, 14–24 mm long, pink-purple, or bicolored; pods erect to ascending, stipitate, or subsessile, the stipe 2–7 mm long, the body oblong-ellipsoid, inflated, 12–34 mm long, 6–13 mm thick, glabrous or puberulent, stiffly papery to leathery, unilocular; ovules 20–44. Two rather distinctive varieties are present in Utah.

1. Pods sessile or nearly so; racemes 4–20 cm long in fruit; plants of southwestern Washington Co. .... *A. preussii* var. *laxiflorus*

— Pods stipitate; racemes 1–9 cm long in fruit; plants of eastern Kane Co. and northeastward .... *A. preussii* var. *preussii*

Var. *laxiflorus* A. Gray. [*A. preussii* var. *laxispicatus* Sheldon; *Phaca laxiflora* (A. Gray) Rydb.]. Creosote bush community at 2200 to 2500 m in the Beaver Dam Mountains, Washington Co.; Nevada. This variety is not known from Utah in modern collections, but contemporary specimens have been seen from Nevada; 1 (0).

Var. *preussii*. [*Phaca preussii* (A. Gray) Rydb.; *Tragacantha preussii* (A. Gray) Kuntze; *Rydbergiella preussii* (A. Gray) Tydb.; *A. preussii* var. *latus* M. E. Jones, type from Green River; *A. preussii* var. *sulcatus* M. E. Jones, type from Westwater; *A. preussii* var. *arctus* Sheldon; *Rydbergiella arcta* (Sheldon) Tydb.; *A. arctus* (Sheldon) Tidestr.; *Jonesiella arcta* (Sheldon) Rydb.]. Blackbrush, mixed desert shrub, and salt desert shrub communities on seleniferous clays and silts at 1170 to 1570 m in Emery, Garfield, Grand, Kane, San Juan and Wayne cos.; Arizona, Nevada, and California. Our materials belong to var. *latus* M. E. Jones, sens, str., which differ from the more western var. *preussii*, sens, str., in having a larger number of leaflets (17–25, not 11–15). Both (in sens. lat.) can be treated conservatively as belonging to a polymorphic var. *preussii*; 54 (xxii).

***Astragalus pubentissimus* Torr. & Gray.** Green River Milkvetch. [*A. multicaulis* Nutt. ex Torr. & Gray, not Ledeb.; *Tragacantha pubentissima* (Torr. & Gray) Kuntze; *Phaca pubentissima* (Torr. & Gray) Rydb.]. Perennial, or functionally annual, caulescent, 9–25 cm tall, from a rather weak caudex; pubescence basifixed; stems decumbent to ascending, radiating from the caudex; stipules 1–4.5 mm long, all distinct; leaves 2–8 cm long; leaflets 5–15, 2–14 mm long, 1.5–5 mm wide, oblong to ovate, obovate, or elliptic, obtuse to retuse, mucronate, or acute, villosulous on both sides; peduncles 1–3.5 cm long; racemes 3- to 12-flowered, the flowers spreading at anthesis, the axis 0.4–3.5 cm long in fruit; bracts 1–3 mm long; pedicels 0.5–2 mm long; bracteoles 0; calyx 4.8–6.3 mm long, the tube 2.8–4.2 mm long, campanulate, villosulous, the teeth 1.8–2.8 mm long, subulate; flowers 8.8–12.2 mm long, pink-purple or ochroleucous and suffused with purple; pods spreading-declined, sessile, inflated, obliquely lance-ellipsoid, 12–20 mm long, 4–8 mm thick, shaggy-pilose, unilocular; ovules 9–18.

1. Plants ascending to erect; flowers monochrome in populations .... *A. pubentissimus* var. *pubentissimus*

— Plants spreading-decumbent; flowers polychrome in populations .... *A. pubentissimus* var. *peabodianus*

Var. *peabodianus* (M. E. Jones) Welsh comb. nov. based on *Astragalus peabodianus* M. E. Jones Zoe 3:295. 1893. The Peabody phase of the Green River milkvetch occurs in entrenched channels cut into the escarpments draining the south and west flanks of the Tavaputs Plateaus, in pinyon-juniper and mixed desert shrub communities at 1300 to 1770 m in Emery and Grand (type from Thompson's Springs) cos.; endemic; 10 (ix).

Var. *pubentissimus*. The Green River milkvetch occurs in pinyon-juniper and mixed desert shrub communities at 1525 to 1925 m in Duchesne and Uintah cos.; Wyoming and Colorado. Reports of livestock poisoning, mainly of sheep, are attributable to this species. In years when it is abundant, the plants constitute the principal forb in much of the lower middle reaches of the Uinta Basin, reminiscent of seeded alfalfa fields among the open juniper-pinyon woodlands; 16 (i).

***Astragalus purshii* Douglas ex Hook.** Pursh Milkvetch. Perennial, acaulescent or subacaulescent, 4.5–13 cm tall, from thatch-clothed caudex branches; pubescence basifixed; stems 0–2 cm long; leaflets 5–17, 2–14 mm long, 1–7 mm wide, elliptic to oblanceolate, acute densely villous on both sides; peduncles 1.5–10.5 cm long; racemes 1- to 7-flowered, the flowers ascending at anthesis, the axis 0.3–2 cm long in fruit; bracts 2–7 mm long; pedicels 1–5 mm long;

bracteoles 0; calyx 12–16 mm long, the tube 8.5–12.5 mm long, cylindric, villous-pilose, the teeth 2.2–6 mm long, subulate; flowers 19–26 mm long, whitish to ochroleucous or pink-purple; pods ascending, sessile, obliquely ovoid, usually curved, 13–26 mm long, 5–11 mm wide, shaggy-villous, unilocular; ovules 20–34. Two varieties are present in Utah.

1. Flowers whitish or ochroleucous, discolorous, the keel purple-tipped; plants of broad distribution in northernmost counties .... *A. purshii* var. *purshii*

— Flowers pink-purple, concolorous; plants rare in Box Elder and Rich cos. .... *A. purshii* var. *glareosus*

Var. *glareosus* **(Douglas) Barneby.** [*A. glareosus* Douglas ex Hook; *Tragacantha glareosa* (Douglas) Kuntze; *A. inflexus* var. *glareosus* (Douglas) M. E. Jones; *Phaca glareosa* (Douglas) Piper; *Xylophacos glareosus* (Douglas) Rydb.]. Sagebrush community at 1530 to 1830 m in Box Elder and Rich cos.; British Columbia south to Nevada. The var. *glareosus* simulates *A. utahensis* (q.v.) both in having pink-purple flowers and in habit. Leaflet shape and the flower structure are important diagnostic features; 2 (0).

Var. *purshii*. [*Tragacantha purshii* (Douglas) Kuntze; *Phaca purshii* (Douglas) Piper; *Xylophacos purshii* (Douglas) Rydb.; *A. purshii* var. *interior* M. E. Jones]. Sagebrush, desert shrub, and pinyon-juniper communities at 1530 to 2270 m in Box Elder, Duchesne, Rich, and Uintah cos.; Washington east to Alberta and Saskatchewan, and south to California, Nevada, Colorado, and South Dakota; 15 (ii).

Astragalus racemosus **Pursh.** Alkali Milkvetch. Perennial, caulescent, 20–53 cm tall, from a branching caudex; pubescence basifixed; stems erect or ascending, forming clumps; stipules 3–8 mm long, at least some connate-sheathing; leaves 4–15 cm long; leaflets 9–19, 3–35 mm long, 1.5–13 mm wide, lance-elliptic to linear-lanceolate, acute to acuminate, glabrous or glabrate on both surfaces, sometimes ciliate; peduncles 3–13 cm long; racemes 9- to 45-flowered, the flowers nodding at anthesis, the axis 5–20 cm long, in fruit; bracts 1.5–7.5 mm long; pedicels 2–8 mm long; bracteoles 0–2; calyx 8.6–12 mm long, the tube 5–6 mm long, short-cylindric, gibbous, glabrous or sparingly strigose, the teeth 3.3–6 mm long, subulate; flowers 14–17 mm long, ochroleucous, concolorous, or with the keel purple-tipped; pods pendulous, stipitate, the stipe 4–6 mm long, the oblong-ellipsoid body 10–21 mm long, 4–8 mm wide, triquetrous, glabrous, unilocular; ovules 12–22. Uinta and Duchesne River formations, rarely otherwise on saline clay and silty soils, at 1570 to 1970 m in Duchesne and Uintah cos; Wyoming. Our plants belong to var. ***treleasei*** **C. L. Porter.** They are primary selenium indicators. Consumption by cattle of this and other selenophyte results in a "alkali disease," or "blind staggers." Plants from along Hill Creek in Uintah Co. have concolorous flowers; those from elsewhere are discolorous; 26 (v).

Astragalus rafaelensis **M. E. Jones.** San Rafael Milkvetch. [*Cnemidophacos rafaelensis* (M. E. Jones) Rydb.]. Perennial, caulescent, rush-like, 32–62 cm tall, from a branching caudex; pubescence basifixed; stems erect or ascending, arranged in clumps; stipules 1–5 mm long, at least some connate-sheathing; leaves 2.5–14.8 cm long, all simple, or some with leaflets 3–5, the lateral ones 3–20 mm long, 0.5–1.5 mm wide, linear to oblong, acute, glabrate beneath, glabrous above, the terminal leaflet longer and confluent with the rachis; peduncles 11–27 cm long; racemes loosely 5- to 12-flowered, the flowers ascending to declined in anthesis, the axis 2–15 cm long in fruit; bracts 1.2–3.5 mm long; pedicels 2–5.5 mm long; bracteoles 2; calyx 6–9.6 mm long, the tube 5.2–7.5 mm long, short-cylindric, thinly strigose to glabrate, the teeth (0.8) 1.1–2.1 mm long, triangular; flowers 19–26 mm long, pale pink-purple or bicolored; pods deflexed, sessile, oblong-elliptic in outline, 12–25 mm long, 5–7 mm wide, laterally compressed, glabrous, leathery-woody, unilocular, ovules 18–20. Seleniferous clays and silts of the Buckhorn Conglomerate, Morrison, Summerville, Chinle, and Moenkopi formations at 1370 to 1625 m in salt desert shrub community in Emery Co.; endemic. There are two main populations; one at the east base of the Cedar Mountain and the other in the vicinity of Window-blind Butte in the San Rafael Swell proper. This is a handsome selenophyte with close affinities to *A. toanus* and *A. saurinus* (q.v.), and lesser affinities to *A. woodruffii* (q.v.) 17 (vii).

***Astragalus sabulonum* A. Gray.** Gravel Milkvetch. [*Phaca sabulonum* (A. Gray) Rydb.; *A. virgineus* Sheldon]. Annual, winter annual, or biennial, caulescent, 4–30 cm tall, radiating from a taproot; pubescence basifixed; stems decumbent to ascending, rarely erect; stipules 1–4 mm long, all distinct; leaves 1.5–7 cm long; leaflets 9–15, 2–13 mm long, 1–5 mm wide, oblanceolate to oblong or obovate, retuse to truncate or obtuse, loosely villous or both surfaces or glabrate above; peduncles 0.5–4 cm long; racemes 2- to 7-flowered, the flowers ascending-spreading at anthesis, the axis 0.3–2 cm long in fruit; bracts 1–2.5 mm long; pedicels 0.8–2 mm long; bracteoles 0; calyx 3.8–5.5 mm long, the tube 1.8–2.5 mm long, campanulate, hirsutulous, the teeth 1.8–3 mm long, subulate; flowers 6.2–8 mm long, pink-purple or less commonly ochroleucous and tinged with purple; pods spreading-declined, sessile, obliquely ovoid, inflated, 9–17 mm long, 5–8 mm thick, curved, white-hirsutulous, unilocular; ovules 10–19. Mixed desert shrub, salt desert shrub, and lower pinyon-juniper communities, often in sand, at 1130 to 1700 m in Emery, Grand, Kane, San Juan, and Wayne cos.; California, Nevada, Arizona, and New Mexico. The gravel milkvetch is a near ally of *A. pardalinus* (q.v.), with which it is at least partially sympatric, and of *A. pubentissimus* whose geographical range is apparently distinct; 21 (vii).

***Astragalus sabulosus* M. E. Jones.** Cisco Milkvetch. [*Jonesiella sabulosa* (M. E. Jones) Rydb.]. Perennial, caulescent, 13–38 cm tall, from a woody caudex; pubescence basifixed; stems decumbent to ascending or erect, forming clumps; stipules 4–9 mm long, all distinct; leaves 3–10.5 cm long; leaflets 5–11, 6–35 (50) mm long, 3–17 mm wide, rhombic-oval to obovate or elliptic, mucronate, strigose to glabrous on both sides; peduncles 3.5–7 cm long; racemes 4- to 10-flowered, the flowers ascending-spreading at anthesis, the axis 0.5–2 cm long in fruit; bracts 2–6 mm long; pedicels 2–5 mm long; bracteoles 0–2; calyx 15–17.5 mm long, the tube 11.5–14 mm long, cylindric, strigulose, the teeth 3–4 mm long, subulate; flowers 28.5–34 mm long, whitish to ochroleucous, fading yellowish; pods spreading to declined, subsessile, inflated, cylindroid, 20–48 mm long, 10–15 mm thick, stiffly papery to leathery, strigose, unilocular; ovules 55–59. Salt desert shrub at 1300 to 1600 m on Mancos Shale east of Thompson in the Grand River Valley in Grand Co.; endemic. The Cisco milkvetch is a primary selenium indicator with close affinities to *A. iselyi* (q.v.), from which it can be distinguished by its larger yellowish flowers. The Cisco milkvetch is also allied with *A. praelongus* which has much smaller flowers and pods. The flowers of *A. sabulosus* are the largest within *Astragalus* in Utah, and possibly elsewhere (though they may not be the longest); 9 (vi).

***Astragalus saurinus* Barneby.** Dinosaur Milkvetch. Perennial, caulescent, rush-like, 25–45 cm tall, from a shallowly subterranean caudex; pubescence basifixed; stems erect or ascending, arranged in clumps; stipules 1.2–7 mm long, usually at least some shortly connate-sheathing; leaves 2.5–9 cm long, the uppermost usually simple, the others with leaflets 3–9, mostly 10–28 mm long, 0.5–2 mm wide, linear to linear-elliptic, obtuse to acute, strigose on both surfaces, the terminal leaflet confluent with the rachis; peduncles 7–21 cm long; racemes 3- to 15-flowered, the flowers ascending-spreading at anthesis, the axis 0.5–6 cm long in fruit; bracts 1.2–2 mm long; pedicels 1.5–3 mm long; bracteoles 1–2; calyx 6.4–9.6 mm long, the tube 5.6–6.7 mm long, cylindric, the teeth 0.9–2.9 mm long, triangular-subulate; flowers 18–22 mm long, bicolored, pink-purple, with white wing-tips, rarely all white; pods deflexed, sessile or nearly so, narrowly oblong in outline, straight or curved, 15–35 mm long, 4.4–6 mm wide, laterally compressed, strigose to glabrate, unilocular; ovules 19–29. Duchesne River, Morrison, Carmel, Chinle, and Moenkopi formations in salt desert shrub and pinyon-juniper communities at 1430 to 1700 m in Uintah Co.; endemic. The dinosaur milkvetch is a primary selenophyte with two near congeners in Utah; *A. toanus* of far western Utah, and *A. rafaelensis* of the San Rafael Swell; 17 (vi).

Astragalus scopulorum **T. C. Porter.** Rocky Mountain Milkvetch. [*Tragacantha scopulorum* (T. C. Porter) Kuntze; *Tium scopulorum* (T. C. Porter) Rydb.]. Perennial, caulescent, 15–48 cm tall, from a shallowly subterranean caudex; pubescence basifixed; stems decumbent to ascending, radiating from the caudex; stipules 3–9 mm long, at least some connate-sheathing; leaves 1.5–8.5 cm long; leaflets 15–29, 2–18 mm long, 1–8 mm wide, oblong to elliptic or oblanceolate, some narrowly so, acute to obtuse or mucronate, thinly strigose to glabrous beneath, glabrous above, thinly ciliate; peduncles 2–14 cm long; racemes 4- to 22-flowered, the flowers declined to nodding at anthesis, the axis 1–7 cm long in fruit; bracts 1.5–7 mm long; pedicels 1–4 mm long; bracteoles 0–2; calyx 9–11.5 mm long; the tube 6.8–8.5 mm long, subcylindric, strigulose, the teeth 1.5–3.5 mm long; flowers 18–24 mm long, ochroleucous, concolorous or the keel faintly purplish; pods pendulous, stipitate, the stipe 4–9 mm long, the body oblong, straight or curved, 18–35 mm long, 3–6.5 mm wide, triquetrous, glabrous, bilocular. Mountain brush, sagebrush, ponderosa pine, pinyon-juniper and aspen-white fir communities at 1670 to 2430 m in Carbon, Grand, eastern Millard, San Juan, Sanpete, Sevier, Summit, Utah, and Wasatch cos.; Colorado, Arizona, and New Mexico. Continued exploration of the plateaus and mountain ranges of central and northern Utah has demonstrated a large area occupied by this distinctive milkvetch of middle elevation brush and woodland; 29 (ix).

Astragalus serpens **M. E. Jones.** Plateau Milkvetch. [*Phaca serpens* (M. E. Jones) Rydb.]. Perennial, caulescent, 3.5–23 cm long, radiating from a weak caudex; pubescence basifixed; stems decumbent to ascending-erect; stipules 1.5–3.5 mm long, all distinct; leaves 1.5–4.5 cm long; leaflets 9–15, 2–9 mm long, 1–4 mm wide, obovate to oblanceolate or elliptic, obtuse to emarginate, strigose-pilosulous beneath and above, or glabrate above; peduncles 0.7–2.5 cm long; racemes shortly 2- to 9-flowered, the flowers spreading at anthesis, the axis 0.2–0.8 cm long in fruit; bracts 1–1.5 mm long; pedicels 1–1.8 mm long; bracteoles 0; calyx 4.2–5 mm long, the tube 2.7–3.5 mm long, campanulate, white strigulose (some black hairs sometimes present), the teeth 1.5–2 mm long, subulate; flowers 6.6–8.6 mm long, purplish to pink-purple or whitish; pods ascending to declined, stipitate, the stipe (gynophore) 0.7–1.5 mm long, the body bladdery-inflated, ovoid or ellipsoid, 13–29 mm long, 7–17 mm wide (when pressed), red-mottled, strigose, unilocular. Sagebrush, pinyon-juniper, aspen, and aspen-fir communities at 2070 to 2800 m in Garfield, Kane, Iron, Piute, and Wayne cos.; endemic. Barneby (1964) places *A. serpens* adjacent to *A. pubentissimus*, a near congener of *A. sabulonum* and *A. pardalinus*. The similarity to *A. perianus* was discounted, but examination of both species in the field and in the herbarium indicates that the nearest ally of *A. serpens* is *A. perianus*, despite the morphological differences noted by Barneby (i.e., the sessile pod, subterranean root-crown, and connate stipules) for *A. perianus*. In some years *A. serpens* is abundant in the Loa Pass vicinity where it occupies spaces between low sagebrush and igneous gravel; 19 (iii).

Astragalus sesquiflorus **S. Wats.** Sandstone Milkvetch. [*Tragacantha sesquiflora* (S. Wats.) Kuntze; *Batidophaca sesquiflora* (S. Wats.) Rydb.; *A. sesquiflorus* var. *brevipes* Barneby]. Perennial, caulescent, prostrate, often mat-forming, 0.5–5 cm tall, radiating from a branching caudex; pubescence malpighian; stems 5–28 cm long or more; stipules 1.5–4.5 mm long, all connate-sheathing; leaves 1–4 cm long; leaflets

7-13, 1.5-10 mm long, 0.6-2 mm wide, elliptic to obovate, acute to obtuse, strigose on both sides (commonly involute); peduncles 0.8-4.5 cm long; racemes 1- to 4-flowered, the flowers ascending at anthesis, the axis very short in fruit; bracts 1.2-3 mm long; pedicels 0.7-4 mm long; bracteoles 0-2; calyx 3.7-5.5 mm long, the tube 1.5-2.8 mm long, campanulate, strigulose, the teeth 1.9-3 mm long, subulate; flowers 6-8 mm long, pink-purple; pods spreading-ascending, sessile or subsessile, the body obliquely oblong in outline, 8-10 mm long, 3-4 mm wide, trigonously compressed, strigulose, mixed desert shrub, pinyon-juniper, and ponderosa pine or aspen communities at 1570 to 2930 m in Kane, San Juan, and disjunctly (accidentally?) in Sanpete cos.; Arizona; a Mohave-San Juan endemic. The sandstone milkevetch is more closely allied to *A. humistratus* than to other species of milkvetch in Utah; 21 (iv).

Astragalus spatulatus **Sheldon.** Draba Milkvetch. [*Homalobus caespitosus* Nutt.; *A. caespitosus* (Nutt.) A. Gray, not Pallas; *Tragacantha caespitosa* (Nutt.) Kuntze; *A. simplificolius* var. *spatulatus* (Sheldon) M. E. Jones; *H. canescens* Nutt. ex Torr. & Gray; *H. brachycarpus* Nutt. ex Torr. & Gray; *A. simplex* Tidestr., not *A. brachycarpus* MB.; *A. spatulatus* var. *simplex* Tidestr.; *H. uniflorus* Rydb.; *A. spatulatus* var. *uniflorus* (Rydb.) Barneby]. Perennial, acaulescent, 1.5-9 cm tall, from a branching caudex; pubescence malpighian; stems obscured by marcescent leaf bases and stipules, tufted, sometimes mat-forming; stipules 2-7 mm long, all connate-sheathing; leaves all or mostly all simple (reduced to phyllodia), 0.8-6 cm long, only rarely with leaflets 3-5 on some leaves and with the terminal one confluent with the rachis, oblanceolate to linear, acute, mucronate, or spinulose, strigose on both surfaces; peduncles 0.4-7 cm long; racemes 1- to 11-flowered, the flowers ascending at anthesis, the axis 0.2-3 cm long in fruit; bracts 0.6-3 mm long; calyx 2.6-5 mm long, the tube 1.9-3.4 mm long, campanulate, strigose, the teeth 0.5-2.5 mm long, subulate; flowers 5.7-9.5 mm long, pink-purplish to ochroleucous or whitish (in populations); pods erect, sessile, lanceolate to lance-oblong in outline, 4-13 mm long, 1.5-3 mm wide, straight or slightly curved, strigose to rarely glabrous, unilocular; ovules 4-12. Pinyon-juniper, sagebrush, and mountain brush communities, often on exposed ridges, at 1530 to 2630 m in Cache, Carbon, Daggett, Duchesne, Emery, Grand, Rich, Uintah, and Wasatch cos. (to be expected in Sanpete and Summit); Alberta and Saskatchewan, south to Idaho, Colorado, and Nebraska. The draba milkvetch is most closely allied to *A. chloodes* and *A. detritalis* among our species; 35 (x).

Astragalus straturensis **M. E. Jones.** Silver Reef Milkvetch. [*Atelophragma straturense* (M. E. Jones) Rydb.; *Hamosa atrata* Rydb., type from southern Utah; *Tium atratiforme* (Rydb.) Rydb.]. Perennial, caulescent, 13-36 cm tall, from a superficial to shallowly subterranean caudex; pubescence basifixed; stems decumbent to ascending or erect, forming clumps; stipules 1-2.5 mm long, all distinct; leaves 3.5-9.5 cm long; leaflets 9-19, 3-13 mm long, 1-5 mm wide, oblong to linear or oval, obtuse or retuse, strigose beneath, glabrous above; peduncles 1.5-7.5 cm long; racemes 9- to 25-flowered, the flowers ascending to declined at anthesis, the axis 1.5-14 cm long in fruit; bracts 0.8-1.5 mm long; pedicels 0.8-1.5 mm long; bracteoles 0; calyx 3.5-4.2 mm long, the tube 2.5-3.5 mm long, campanulate, strigose, the teeth 0.7-1 mm long, triangular; flowers 6.5-8.5 mm long, pink-purple with white wing-tips; pods pendulous, stipitate, the stipe 1.4-2 mm long, the body oblong in outline, curved or straight, 10-15 mm long, 2.2-3 mm wide, strigose, bilocular; ovules 10-13. Sagebrush, pinyon-juniper, and mountain brush communities at 1530 to 2130 m in Beaver, Iron, southeastern Millard, and Washington (type from Silver Reef) cos.; Arizona and Nevada. The Silver Reef milkvetch has no close relatives in the milkvetch flora of Utah. In flower size and general habit, it resembles *A. wingatanus* of southeastern Utah, but the resemblance is only superficial; 10 (iii).

Astragalus striatiflorus **M. E. Jones.** Escarpment Milkvetch. Perennial, subacaulescent to short-caulescent, 1.5-6 cm tall, radiating from a branching, usually subterranean caudex; pubescence basifixed; stems 0–5 cm long, only the tips produced above the sand; stipules 2–4 mm long, all connate-sheathing; leaves 1–4 cm long; leaflets 5–13, 1–7 mm long, 0.8–2.5 mm wide, ovate to obovate or oblanceolate, obtuse, mucronate, or emarginate, pilosulous; peduncles 1–3 cm long; racemes 2- to 5-flowered, the flowers ascending in anthesis, the axis 0.2–1 cm long; pedicels 1–1.5 mm long; bracteoles 0; calyx 5.5–7 mm long, the tube 3–4 mm long, campanulate, hirsutulous, the teeth 1.8–3 mm long, subulate; flowers 9–12 mm long, pink-purple or whitish and commonly suffused with purple, the keel-tip purple, long-attenuated, with the stigma protruding; pods spreading, sessile, the body bladdery-inflated, ellipsoid, 12–18 mm long, 8–15 wide (when pressed), mottled, spreading-hairy, bilocular. Interdune valleys, sandy depressions on ledges, and bars and terraces in stream channels at 1530 to 1900 m in Kane (from the Paria River westward) and eastern Washington cos.; Coconino Co., Arizona. The escarpment milkvetch is a singular plant, resembling *A. perianus* more closely than any other in Utah. The attenuate keel-tip, protruding stigma, and inflated bilocular pods are both unusual and diagnostic features; 12 (iv).

***Astragalus subcinereus* A. Gray.** Silver Milkvetch. [*Phaca subcinerea* (Gray) Rydb.; *A. sileranus* M. E. Jones, type from Sink Valley (near Alton); *Phaca silerana* (M. E. Jones) Rydb.; *A. sileranus* var. *cariacus* M. E. Jones, type from Elk Head Ranch on the upper Virgin River]. Perennial, caulescent, prostrate, 14–90 cm long, radiating from a subterranean branching caudex; pubescence basifixed; stems prostrate to weakly ascending; stipules 1.5–6.5 mm long, at least some connate-sheathing; leaves 1.5–8.5 cm long; leaflets 9–23, 2–16 mm long, 1–8.5 (10) mm wide, oblong to oblanceolate or obovate, obtuse, emarginate, or retuse, villosulous on both surfaces, or glabrate above; peduncles 1.5–10 cm long; racemes 5- to 37-flowered, the flowers ascending to declined at anthesis, the axis 1–7 cm long in fruit; bracts 1–3 mm long; pedicels 0.5–2.5 mm long; bracteoles 0–1; calyx 3.4–6.3 mm long, the tube 2.3–3.6 mm long, campanulate, villosulous, the teeth 0.9–2.9 mm long, subulate; flowers 6–11 mm long, ochroleucous and commonly suffused with purple; pods spreading to declined, subsessile, inflated, ovoid-ellipsoid to ellipsoid, 12–27 mm long, (3.5) 6–13 mm wide (when pressed), subterete to dorsiventrally compressed, thinly villosulous, mottled; ovules 10–20. Barneby (1964: 214) discussed the variation within *A. subcinereus* sens. lat. noting the morphological variants in each major segment of the species at large. Much of the material from Kane, Garfield, and Washington counties differs from the typical plants in Mohave County, Arizona in being more leafy (the leaflets 4–10 mm broad), in having longer stems (3–7 dm long), and in having more firmly walled pods 15–28 mm long and 6–10 (13) mm thick. These Utah plants belong, sens. str., to var. *cariacus* M. E. Jones, but the features are weak and overlapping at best. There is another variant, not seen by Barneby, that is seemingly worthy of taxonomic recognition. It is separable as follows:

1. Mature pods elliptic-oblong to oblong, 3.5–5.5 mm wide; flowers 8.5–11 mm long; stems 40–90 cm long; plants of volcanic gravels in eastern Sevier and Emery cos. .... *A. subcinereus* var. *basalticus*

– Mature pods ovoid-ellipsoid, 6–13 mm wide; flowers 6–9 mm long; stems mostly 14–70 cm long; plants commonly of sedimentary gravels, sometimes from igneous gravels, but not in Sevier or Emery cos. .... *A. subcinereus* var. *subcinereus*

Var. *basalticus* Welsh var. nov. *Astragalo subcinereo* var. *subcinero* aemulans, differt leguminibus angustioribus (3.5–5.5 mm, nec 6–13 mm), floribus magnioribus (8.5–11 mm, nec 6–9 mm), et caulis longioribus (40–90 cm, nec 14–70 cm). Holotype. Utah, Sevier Co., open pine woodland adjacent to Utah Highway #72, ca. 10 miles south of junction with Utah Highway #4, Welsh, Isely, Moore 6447, 23 July 1967 (BRY). Paratypes: Utah, Emery Co., 7 mi S of I-70, Road to Baker Ranch, Welsh 14788, 18 May 1977 (BRY); Sevier Co., igneous bouldery slope with juniper, along Utah Highway #72, 5 miles south of junction with Utah Highway #4, Welsh, Isely, Moore 6445, 23 July 1967 (BRY) 12 mi due SSW of Emery, Welsh & Clark 16186, 23 Aug 1977 (BRY). The plants grow at 1830 to 2430 m in pinyon-juniper and sparse ponderosa pine woods in Emery and Sevier cos.; endemic; 4 (iv).

Var. ***subcinereus.*** Ponderosa pine, pinyon-juniper, and sagebrush communities at 1670 to 2270 m in Garfield, Iron, Kane, and Washington cos.; Lincoln Co., Nevada, and Mohave and Coconino cos.; Arizona; 13 (ii).

Astragalus tenellus **Pursh.** Pulse Milkvetch. [*Ervum multiflorum* Pursh; *Homalobus multiflorus* (Pursh) Nutt. ex Torr. & Gray; *A. multiflorus* (Pursh) A. Gray; *Tragacantha multiflora* (Pursh) Kuntze; *H. tenellus* (Pursh) Britton in Britton & Brown; *H. strigulosus* Rydb.; *A. tenellus* f. *strigulosus* (Rydb.) Macbr.; *A. tenellus* var. *strigulosus* (Rydb.) F. J. Hermann]. Perennial, caulescent, 10–52 cm tall, from a branching caudex; pubescence basifixed; stems erect, ascending, or less commonly decumbent, forming clumps; stipules 1.5–7 mm long, turning black in drying, at least some connate-sheathing; leaves 2–9 cm long; leaflets 11–21, 3–24 mm long, 0.4–6 mm wide, narrowly oblong to elliptic, linear, oblanceolate or obovate, acute to obtuse, mucronate, or emarginate, thinly strigose beneath, glabrous above; peduncles 0.2–4 cm long, often paired; racemes (1) 3- to 23-flowered, the flowers ascending at anthesis, the axis 0.5–11 cm long in fruit; bracts 0.5–2.7 mm long; pedicels 0.7–3.2 mm long; bracteoles 0–2; calyx 2.6–5.2 mm long, the tube 2–2.7 mm long, campanulate, strigose, the teeth 0.7–2.5 mm long; flowers 6–9 mm long, white to ochroleucous; pods pendulous, stipitate, the stipe 0.6–5.5 mm long, the body elliptic to oblong in outline, straight or curved, 7–16 mm long, 2.5–4.5 mm wide, laterally flattened, glabrous or less commonly strigose, unilocular; ovules 3–9. Mountain brush, sagebrush, pinyon-juniper, ponderosa pine, aspen-fir, and spruce-fir communities at 1670 to 2900 m in Box Elder, Cache, Carbon, Daggett, Duchesne, Emery, Garfield, Grand, Iron, Millard, Piute, Sanpete, Sevier, Summit, Uintah, Utah, Wasatch, and Wayne cos.; Yukon east to northern Manitoba and south to Nevada, New Mexico, Nebraska, and Minnesota. The pulse milkvetch is similar to many salient morphological features to *A. wingatanus*, but the subterranean caudex, habit of growth, and elongated fruiting racemes of that species indicate affinities elsewhere, even though the fruit and the tiny flowers are similar; 90 (xx).

Astragalus tephrodes **A. Gray.** Ashen Milkvetch. [*A. shortianus* var. *brachylobus* A. Gray; *Xylophacos brachylobus* (A. Gray) Rydb.; *A. curtilobus* Tidestr., not *A. brachylobus* DC.]. Perennial, acaulescent to short-caulescent, 5–15 cm tall, from a branching caudex; pubescence basifixed; stems 0–8 cm long, the internodes commonly obscured by stipules; stipules 2–11 mm long, all distinct, or rarely some shortly connate-sheathing; leaves 4–16 cm long; leaflets 11–31, 3–17 mm long, 2–11 mm broad, obovate to oblanceolate, elliptic, or orbicular, obtuse, acute, or emarginate, strigulose to pilosulous on both sides or glabrous above; peduncles 4–15 cm long; racemes 10- to 25-flowered the flowers ascending at anthesis, the axis 1.5–8 cm long in fruit; bracts 1.5–9 mm long; pedicels 0.6–3.4 mm long; bracteoles 0; calyx 8.8–12.7 mm long, the tube 7.1–10 mm long, cylindric, pilosulous, the teeth 1.7–2.8 mm long, subulate; flowers 15–24 mm long, pink-purple; pods ascending, ellipsoid to lance-ellipsoid, 17–30 mm long, 6–10 mm thick, strigulose to pilosulous, unilocular; ovules 24–35. Known in Utah with certainty only on the basis of a collection reported by Barneby (1964) from Washington Co. (Springdale, Jones in 1894, POM); California, Arizona, and New Mexico. Our material reportedly belongs to **var. *brachylobus* (A. Gray) Barneby.**

Astragalus tetrapterus **A. Gray.** Fourwing Milkvetch. [*Pterophacos tetrapterus* (A.

Gray) Rydb.]. Perennial, caulescent, 10–35 cm tall, from a subterranean caudex; pubescence basifixed; stems erect or ascending, or finally decumbent; stipules 2–5.5 mm long, all distinct; leaves 1.5–8.5 cm long; leaflets 9–21, 1–33 mm long, 0.3–3.2 mm wide, linear, narrowly oblong, or elliptic, obtuse to acute, strigose to glabrous on both sides, at least some terminal leaflets confluent with the rachis in uppermost leaves; peduncles 1–6.5 cm long; racemes 6- to 15-flowered, the flowers ascending at anthesis, the axis 1–4 cm long in fruit; bracts 1.5–3.5 mm long; pedicels 1.4–4.3 mm long; bracteoles 0–2; calyx 5.5–8.7 mm long, the tube 4.7–7 mm long, cylindric, strigose, the teeth 0.8–2.8 mm long, subulate; flowers 15–19 mm long, white to yellowish tinged faintly with pink, the keel faintly purple-tipped; pods pendulous, sessile, obliquely oblong in outline, curved or coiled, 20–40 mm long, 6–10 mm wide, succulent at first, ultimately (by collapse of fleshy walls), sharply 4-angled, glabrous or strigose, unilocular; ovules 28–38. Pinyon-juniper and sagebrush communities at 1030 to 2130 m in Beaver, Iron, Kane, and Washington (type from 25 miles north of St. George) cos.; Oregon, Nevada, and Arizona. The four-wing milkvetch has been reported to produce locoism in livestock, but it is seldom sufficiently abundant to produce serious, large-scale losses; 9 (iii).

***Astragalus toanus* M. E. Jones.** Toana Milkvetch. [*Cnemidophacos toanus* (M. E. Jones) Rydb.]. Perennial, caulescent, rush-like, 15–50 cm tall, from shallowly subterranean to superficial caudex; pubescence basifixed; stems erect or ascending, in clumps; stipules 1.5–6.5 mm long, at least some connate-sheathing; leaves 2–10 cm long, the uppermost, rarely all, simple, or with the terminal leaflet confluent with the rachis, the lower ones with leaflets 3–9, 3–30 mm long, 1.4–2.5 mm wide, linear-filiform to oblong, obtuse to acute, strigose or glabrous on both sides; peduncles 6–25 cm long; racemes 7- to 35-flowered, the flowers ascending at anthesis, the axis 3–30 cm long in fruit; bracts 1–3 mm long; pedicels 0.8–3.5 mm long; bracteoles 0–2; calyx 4.6–8 mm long, the tube 4.1–6.4 mm long, short-cylindric, strigose, the teeth 0.5–2 mm long, subulate; flowers 15–20 mm long, pink-purple with wing-tips white; pods erect, sessile, oblong in outline, 13–25 mm long, 3.7–5.5 mm wide, slightly compressed laterally glabrous to strigose, unilocular; ovules 14–26. Seleniferous clay soils in salt desert shrub communities at 1530 to 1770 m in Box Elder and Millard cos.; Nevada, Oregon, and Idaho. The Toano milkvetch has affinities with both *A. saurinus* of the Uinta Basin, and *A. rafaelensis* of the San Rafael Swell. No intermediates are known; 12 (i).

***Astragalus utahensis* (Torr.) Torr. & Gray.** Utah Milkvetch. [*Phaca millissima* var. *utahensis* Torr. in Stansbury; *Tragacantha utahensis* (Torr.) Kuntze; *Xylophacos utahensis* (Torr.) Rydb.]. Perennial, subacaulescent, mostly 2–12 cm tall, radiating from a branching caudex; pubescence basifixed; stems 0–10 cm long, the internodes usually concealed by stipules, prostrate; stipules 3–10 mm long, all distinct; leaves 1.5–12 cm long; leaflets 9–19, 2–15 mm long, 2–12 mm wide, obovate or suborbicular to ovate, obtuse to emarginate, rarely acute, densely villous-tomentose on both surfaces; peduncles 1–14 cm long; racemes 2- to 8-flowered, the flowers ascending at anthesis, the axis 0.4–2.6 cm long in fruit; bracts 4–9 mm long; pedicels 2–4.3 mm long; bracteoles 0–2; calyx 12–14 mm long, the tube 8.5–13 mm long, cylindric, villous-tomentose, the teeth 2–4.5 mm long, lance-subulate; flowers 23–31 mm long, pink-purple (rarely white); pods ascending, sessile or stipitate, the stipe (gynophore) 1–2.5 mm long, the body 17–30 mm long, 5.5–7.5 mm wide, obscured by long shaggy-villous hairs, unilocular; ovules 22–31. Sagebrush, pinyon-juniper, mountain brush, and grassland communities at 1250 to 2130 m in all Utah counties except Daggett, Emery, Grand, Iron (to be expected), Kane, Rich, San Juan, and Uintah; Idaho and Nevada. The Utah milkvetch is known locally as "ladyslipper," because of a fancied resemblance of the large flowers to softly cushiony house-slippers. The plants are abundant along the Wasatch front, where they flower in April and May, much to the delight of beginning students in taxonomy, each of whom feels compelled to collect at least one plant and deposit it in a herbarium; 163 (xii).

Astragalus wardii **A. Gray.** Ward Milkvetch. [*Phaca wardii* (A. Gray) Rydb.]. Perennial, caulescent, 9–50 cm tall, from a branching, superficial (rarely subterranean) caudex; pubescence basifixed; stems decumbent to erect; stipules 1–3 mm long, all distinct; leaves 3–10 cm long; leaflets 17–23, 3–11 mm long, 0.8–6 mm wide, oblanceolate to elliptic or narrowly oblong to linear, obtuse to retuse or emarginate, strigose only on the midrib beneath and on margins; peduncles 1.5–5 cm long; racemes loosely 5-to 15-flowered, the flowers ascending to declined at anthesis, the axis 1–5 cm long in fruit; bracts 1–2.2 mm long; pedicels 1–3.4 mm long; bracteoles 0–2; calyx 2.9–4.6 mm long, the tube 1.7–2.3 mm long, campanulate, strigose with black, less commonly black mixed with white, hairs, the teeth 1–2.4 mm long, subulate; flowers 5–8 mm long, whitish or ochroleucous; pods pendulous to spreading, sessile or on a gynophore about as broad as long, bladdery-inflated, 15–28 mm long, 9–17 mm wide (when pressed), mottled or not, glabrous, unilocular; ovules 12–17. Sagebrush, cottonwood, pinyon-juniper, ponderosa pine and spruce-fir communities, or less commonly in grassland and salt desert shrub communities, at 1530 to 2730 m in Garfield, Kane, Piute, and Sevier cos.; endemic. The Ward milkvetch is similar in its inflated, unilocular pods, distinct stipules, and small flowers with the closely contiguous, if not sympatric, *A. serpens*, from which it can be distinguished by the more numerous leaflets, predominately black strigose calyces, and glabrous pods. The presence of an incipient gynophore in *A. wardii* strengthens the similarity between these distinctive species; 24 (ii).

Astragalus wetherillii **M. E. Jones.** Wetherill Milkvetch. [*Phaca wetherillii* (M. E. Jones) Rydb.]. Perennial, caulescent, 4–26 cm tall, from a branching caudex; pubescence basifixed; stems decumbent to ascending, in clumps; stipules 1.2–3.5 mm long, all distinct; leaves 2–10 cm long; leaflets 7–15, 3–14 mm long, 2–9 mm wide, obovate to oval, obtuse to emarginate or mucronate, thinly strigose beneath, glabrous above; peduncles 1.5–4.5 cm long; racemes 2- to 9-flowered, the flowers ascending to declined at anthesis, the axis 0.3–2.3 mm long in fruit; bracts 1–2.5 mm long; pedicels 1–2.5 mm long; bracteoles 0; calyx 4.6–6.2 mm long, the tube 2.8–3.8 mm long, campanulate, strigose, the teeth 1.8–2.4 mm long, subulate; flowers 7.5–11 mm long, whitish or tinged lavender; pods spreading to declined or shortly stipitate, the stipe (gynophore) 1–2.5 mm long, the body inflated, ovoid-ellipsoid, slightly curved, 14–22 mm long, strigulose, unilocular; ovules 9–13. Mountain brush and pinyon-juniper communities at 1430 to 1770 m in Grand Co. (collected by Eastwood according to Jones 1923); central western Colorado. The Utah collection is known from the canyon of the Colorado River east of Moab. It has not been recollected in many years, but likely it persists along the canyon slopes on the shaded side. It is a peculiar species, not quite like any other known from Utah. The pods of early produced flowers are often mature and brown while progressively younger pods and flowers continue to be produced as the plants elongate; 2 (ii, both from Colorado).

Astragalus wingatanus **S. Wats.** Fort Wingate Milkvetch. [*Homalobus wingatanus* (S. Wats.) Rydb.; *A. dodgeanus* M. E. Jones, type from Thompson's Springs; *A. wingatanus* var. *dodgeanus* (M. E. Jones) M. E. Jones]. Perennial, caulescent, 15–45 (60) cm tall, from a subterranean caudex; pubescence basifixed; stems spreading-ascending, forming diffuse clumps; stipules 1.5–5 mm long, at least some connate-sheathing; leaves 1.5–6.5 cm long; leaflets 7–15 (17) 3–18 mm long, 0.4–3.6 mm wide, linear to narrowly oblong, elliptic or oblanceolate, acute, obtuse, or retuse, strigose to glabrous beneath, glabrous above, often ciliate; peduncles 2–14 cm long; racemes very loosely 7- to 35-flowered, the flowers ascending at anthesis, the axis 3–18 cm long in fruit; bracts 0.5–2 mm long; pedicels 0.8–3 mm long; bracteoles 0–2; calyx 2.5–3.7 mm long, the tube 1.5–2.6 mm long, campanulate, strigose, the teeth 0.4–1.4 mm long, triangular-subulate; flowers 5.5–8 mm long, pink-purple, the wing-tips white or pale; pods deflexed, subsessile or short-stipitate, the stipe to 1.7 mm long, the body elliptic to oblong in outline, straight or slightly curved, 9–15 mm long, 3–4.5 mm wide, compressed, glabrous, unilocular; ovules 4–8. Pinyon-juniper, mixed desert shrub, salt desert shrub, and less commonly in mountain brush communities at 1530 to 2130 m in Carbon, Duchesne, Emery, Grand, and San Juan cos.; Colorado, New Mexico, and Arizona. The Fort Wingate milkvetch simulates *A. tenellus* (q.v.), in its small flowers and laterally flattened pods. The buried caudex and elongated fruiting racemes are diagnostic for *A. wingatanus*, and indicate relationships elsewhere (i.e., with scytocarpous taxa such as *A. flexuosus* var. *diehlii*); 29 (xii).

Astragalus woodruffii **M. E. Jones.** Woodruff Milkvetch. [*Homalobus woodruffii* (M. E. Jones) Rydb.]. Perennial, caulescent, rush-like, 25–55 (65) cm tall, from a deeply subterranean caudex; pubescence basifixed or incipiently malpighian; stems erect or ascending in broom-like clumps; stipules 10–25 mm long, at least some usually connate-sheathing; leaves 1.5–6.5 (8) cm long, at least the upper ones simple, the others with decurrent leaflets 2–9, 2–17 mm long, 0.5–2 mm wide, acute to obtuse, silvery-strigose on both surfaces, the terminal leaflet decurrent also; peduncles 3.5–16 cm long; racemes 8- to 45-flowered, the flowers ascending at anthesis, the axis 2–25 cm long in fruit; bracts 2.5–7 mm long; pedicels 1–5 mm long; bracteoles 0–2; calyx 7.2–10.9 mm long, the tube 4.2–6.6 mm long, short-cylindric, pilosulous, the teeth 2.7–6 mm long, lance-subulate; flowers 12–19 mm long, pink-purple with pale or white wing-tips; pods erect, sessile, oblong in outline, straight to slightly curved, 14–20 mm long, 3.5–4.8 mm wide, laterally compressed, strigose, unilocular. Seleniferous, sandy or sandy-silts with sandloving desert shrubs at 1330 to 1670 m in southeastern Emery (type from San Rafael Swell), eastern Garfield and Wayne cos.; endemic. The Woodruff milkvetch has affinities with *A. rafaelensis*, *A. saurinus*, and *A. toanus*, but has been placed in a section by itself by Barneby (1964: 436). The species was described by Jones (1923: 78) as being "the most beautiful species of the genus when the whole mass is ablaze with pink-purple bloom." The plant is a primary selenium indicator; 21 (vii).

Astragalus zionis **M. E. Jones.** Zion Milkvetch. [*Xylophacos zionis* (M. E. Jones) Rydb.]. Perennial, subacaulescent or short-caulescent, 3–23 cm tall, from a branching caudex, this sometimes clothed with a persistent thatch of leaf bases; pubescence basifixed; stems 0–11 cm long, prostrate to ascending, the internodes often concealed by stipules; stipules 1.5–5.5 mm long, all distinct or some shortly connate-sheathing; leaves mostly 2–15 cm long; leaflets 13–25, 2–16 mm long, 1–6 mm wide, elliptic or ovate, acute or less commonly obtuse, silvery villous on both sides; peduncles 0.5–15 cm long; racemes 1- to 11-flowered, the flowers ascending at anthesis, the axis 0.3–6 cm long in fruit; bracts 2–5 mm long; pedicels 1–3 mm long; bracteoles 0–2; calyx 8.3–18 mm long, the tube 6.5–12.7 mm long, cylindric, villous, the teeth 1.5–5.7 mm long, subulate; flowers 18–26 mm long, pink-purple or sometimes pale; pods ascending, sessile, obliquely ovoid-oblong in outline, 15–30 mm long, 5.5–9 mm wide, usually curved, dorsiventrally compressed, strigose or villosulous, brightly mottled, usually unilocular; ovules 24–30. On sandstone and in sandy and gravelly soils in mixed desert shrub, mountain brush, and riparian communities at 1130 to 2430 m in Garfield, Kane, San Juan, and Washington cos.; Arizona. The Zion milkvetch is allied to *A. argophyllus* from which it differs in the connate stipules and brightly mottled pods. The habitat of *A. argophyllus* is seldom situated in sand, while that of *A. zionis* is almost exclusively restricted to it; 31 (vi).

CAESALPINIA L.

Unarmed shrubs, glandular-punctate in part; leaves alternate, bipinnate, petiolate, the pinnae bearing several leaflets; stipules small, persistent; flowers several to many, borne in racemes, the axis of the raceme densely glandular; calyx 5-lobed; corolla irregular; petals 5, conspicuous, the uppermost not enclosing the others in bud; stamens 10, long-exserted, brightly colored and showy, distinct; pistils sessile; pods flattened, dehiscent.

Caesalpinia gilliesii (Wallich) Dietrich. Poinciana, Bird-of-paradise. [*Poinciana gilliesii* Wallich ex Hook.; *Erythrosetmon gilliesii* (Wallich) Klotzsch]. Shrubs, commonly (1) 1.5–2.5 m tall; leaves 15–28 cm long, with 8–12 pairs of pinnae, each with 7–11 pairs of elliptic to oblong leaflets 3–8 mm long, glabrous; petioles 2–4 cm long, glabrous; racemes 10–40 cm long, terminal, the peduncle and rachis conspicuously viscid-glandular; pedicels 1.5–3 cm long; flowers very showy; sepals distinct, 15–20 mm long, stipitate glandular and puberulent; petals yellow with orange markings, 20–35 mm long; staminal filaments red, 6–9 cm long; pods ascending, sessile, oblong in outline, 55–120 mm long, 14–20 mm wide, glandular-dotted, dehiscent. Cultivated ornamental of startling beauty at low elevations in Washington Co.; Texas to California. Plantings in St. George and in Beaver Dam Wash persist and spread, finally becoming established. This is a remarkable addition to the flora of the state; 3 (ii).

CARAGANA Lam.

Shrubs; leaves alternate, even-pinnate, the rachis extended as a bristle or spine; stipules small and deciduous or persistent as spines; flowers solitary, yellow, showy; calyx campanulate or turbinate, obscurely to conspicuously 5-toothed; corolla papilionaceous; stamens 10, diadelphous; ovary sessile; pods subcylindric, linear-oblong, straight, glabrous, elastically dehiscent, the valves coiling upon dehiscence.

Caragana arborescens Lam. Pea Tree. [*Robinia caragana* L.; *C. sibirica* Medicus; *C. inermis* Moench; *C. caragana* (L.) Karstin; *Aspalathus caragana* (L.) Kuntze]. Shrubs to 4 m tall or more; leaves 4–10 cm long; leaflets 8–12, 12–25 mm long, 5–15 mm wide, lance-oblong to elliptic or oval, cuspidate, villous above and below, becoming glabrate in age; stipules slender, occasionally persisting as spines; bracts reduced to rudiments at juncture of peduncle and pedicel; flowers 17–23 mm long, borne singly on peduncles 12–35 mm long, few to several from each bud; pedicels 5–15 mm long; calyx turbinate, pubescent, the tube 4.5–7.5 mm long, the teeth small or obsolete, the margin villous; pods ascending to declined, sessile, linear-oblong, straight 35–55 mm long, 4–7 mm thick, glabrous, the valves drying brown. Cultivated ornamental and erosion-control plant in Kane, Salt Lake, Sevier, Sanpete, Summit, and Utah cos., and probably throughout Utah (not adequately collected); introduced from central Siberia; 12 (ii). There are several other species of *Caragana* growing in North America, all introduced from the Old World. It is expected that several of these should find use in ornamental, hedge, windbreak, and erosion control plantings in the future.

CERCIS L.

Small trees or shrubs; leaves alternate, simple, palmately veined, cordate-obvate or orbicular; stipules deciduous; flowers clustered, appearing before leaves from spurs on old branches or cauliflorus, pink, showy; calyx turbinate-campanulate, shallowly 5-lobed; corolla irregular, the keel larger than the banner; stamens 10, distinct; ovary subsessile; pods short-stipitate laterally flattened, the ventral suture somewhat winged, indehiscent or tardily dehiscent.

1. Leaves ovate- or cordate-acuminate; flowers 9–12 mm long; plants cultivate, introduced .... *C. canadensis*

— Leaves cordate-reniform or broader than long, rounded or emarginate, not acuminate apically; flowers 12–14 mm long or more .... *C. occidentalis*

Cercis canadensis L. American Redbud; Judas Tree. Shrub or small tree, mostly 1.5–3 m tall, rarely more; leaves commonly ovate-cordate, truncate to cordate basally, acuminate to acute apically, 3.5–10 cm long, longer than broad to somewhat broader than long, glabrate to puberulent beneath; flowers appearing before the leaves, clustered on spurs, cauliflorus; pedicels 6–10 mm long; calyx asymmetric, 2.5–3.5 mm long, 4.3–6.3 mm wide; corolla pink (pink-purple), 9–12 mm long; keel petals 3.8–5 mm wide; pods pendulous-spreading, laterally flattened, 40–80 mm long, 8–18 mm wide, winged, the wings 0.8–2.1 mm wide, glabrous. Cultivated ornamental at 1370 to 1570 m in Salt Lake and Utah cos., and undoubtedly elsewhere; introduced from the eastern U.S., where indigenous from Nebraska south to Texas and east to the Atlantic. Our materials seem to belong to var. *canadensis*; 9 (i).

***Cercis occidentalis* Torr. ex A. Gray.** Western Redbud. Small tree or less commonly a shrub, mostly 1.5–3.5 m tall, rarely more; leaves cordate-reniform, cordate basally, rounded to emarginate apically, 2–7 cm long, commonly broader than long, glabrous or puberulent along vein axils beneath; flowers appearing before the leaves, clustered on spurs, cauliflorus; pedicels 8–12 mm long; calyx asymmetric, 3–4.5 mm long, 5.5–8 mm wide; corolla pink to pink-purple, 12–15 mm long; keel petals 5.5–8 mm wide; pods short-stipitate, 40–100 mm long, 13–20 mm wide, winged, the wings 1.5–2.5 mm wide, glabrous. Indigenous, or rarely cultivated, at 770 to 1230 m in sandstone canyons and alcoves in Garfield, Kane, Salt Lake (in cultivation), San Juan, and Washington cos.; California, Nevada, and Arizona. Variation in *Cercis* has been summarized by Isely (1975). Our material was recognized by that worker as being distinctive as a population when compared to typical California specimens. Plants from Utah, Arizona, and Nevada clearly belong to var. ***orbiculata* (Greene) Tidestr.** in Tidestr. & Kittell (*C. orbiculata* Greene, type from Diamond Valley, Washington Co.); 32 (v).

CLADRASTIS Raf.

Unarmed trees; leaves alternate, odd-pinnately compound, petiolate; stipules lacking; axillary buds covered by the leaf base; flowers in panicles, white, showy; calyx turbinate-campanulate, 5-toothed, stamens 10, distinct or nearly so, included; ovary stipitate; pods pendulous with the panicles, oblong in outline, laterally flattened, often irregularly constricted (by abortion of the seeds), dehiscent.

***Cladrastis kentukea* (Dum.-Cour.) Rudd.** Yellow-wood. [*Sophora kentukea* Dum.-Cour.; *Virgillia lutea* Raf.; *C. lutea* (Michx.) K. Koch; *C. tinctoria* Raf.]. Tree to 10 m tall, rarely more; bark smooth; wood yellow; leaves 15–32 cm long; leaflets 7–9 (11), 4–11 cm long, 2.3–7 cm wide, elliptic to ovate or obovate, acute to obtuse basally, acuminate to acute or obtuse apically, borne on petiolules, glabrous; panicles 20–40 cm long; flowers numerous, white, 15–25 mm long; calyx 8.5–9.5 mm long, villous, the rounded lobes 1.2–1.8 mm long, densely villous; pods stipitate, the stipe 4–6 mm long, usually shorter than the calyx, the body 55–80 mm long, 8–10 mm wide, flattened, glabrous. Cultivated ornamental flowering tree of lower elevations in Cache, Salt Lake, and Utah cos., and likely elsewhere; introduced from eastern U.S. This is a beautiful tree, worthy of being cultivated more widely than at present; 3 (0).

COLUTEA L.

Unarmed shrubs; leaves alternate, odd-pinnately compound, petiolate; stipules more less persistent, papery; flowers in racemes, yellow, showy; calyx turbinate-campanulate, 5-toothed; petals papilionaceous; stamens diadelphous, 9 and 1; ovary stipitate, the style hirsute along the ventral margin; pods pendulous, bladdery-inflated, strigulose, the incurved style persistent.

***Colutea arborescens* L.** Bladder-senna. Shrubs, 1.2–3.5 m tall, sometimes dying to the ground; herbage strigose; leaves 6–12.5 cm long; leaflets 9–13, 14–23 (30) mm long, 7.5–12.5 mm wide, obovate to oblanceolate or elliptic, rounded to emarginate, mucronate, strigose beneath, glabrous above, the veins apparent; racemes 4- to 11-flowered; pedicels 3.5–9 mm long; bracts 1.2–4.2 mm long; bracteoles 2; calyx 4.5–7.5 mm long, the tube 4.2–5.2 mm long, the teeth 1.2–2.2 mm long; flowers 16–22 mm long, yellow, the banner abruptly reflexed, the wings strongly angled upwards, surpassed by the keel; pods stipitate, the stipe 6–10 mm long, the body bladdery-inflated, ellipsoid, 45–60 mm long (or more), 16–24 mm wide (when pressed), usually mottled, indehiscent. Bladder-senna is a cultivated shrub, mainly as an ornamental in Salt Lake and Utah cos., but recently it has been used in erosion control plantings, especially on clay soils along roadways in Juab and Sanpete cos., at elevations of 1670 to 2500 m; introduced from southern Europe and Africa; 4 (i).

CORONILLA L.

Perennial herbs, caulescent, from a taproot and caudex; leaves alternate, pinnately compound; stipules herbaceous, becoming chartaceus; flowers papilionaceous, in axillary pedunculate umbels; bracts minute, scarious; calyx 5-toothed; petals 5, pink or white, the keel long-attenuate; stamens 10, diadelphous; ovary enclosed in the staminal sheath, the style glabrous; fruit a loment, 4-angled.

Coronilla varia L. Crown Vetch. Perennial, 30–105 cm long, with spreading stems, glabrous to scabrous; stipules small; leaflets 9–23, 5–21 mm long, 1.5–11 mm wide, oblong to obovate or oblanceolate, acute to retuse apically; peduncles 3–11 cm long; bracts minute; flowers 11–20, 9–12 mm long; calyx 1.5–2 mm long, the teeth much shorter than the tube; loments 35–50 mm long. Cultivated erosion control plant, escaping and persisting, Sevier and Utah cos.; widespread in Western states; introduced from Europe; 2 (i).

CYTISUS L.

Deciduous or evergreen shrubs; leaves alternate, 3-foliolate or simple; stipules minute, thickened; flowers papilionaceous, axillary, solitary or sometimes 2 or 3; bracts minute; calyx bilabiate, the upper lip 2-lobed, the lower 3-lobed; petals 5, yellow, the keel not especially alternate; stamen 10, monadelphous, with 4 longer than the other, the style curved, broadened near the concave top; pods flattened, several-seeded.

Cytisus scoparius (L.) Link. Scots Broom. Shrubs to 2 m tall or more, the branchlets green, strongly angled; leaves 3-foliolate, becoming simple upwards; flowers solitary, rarely 2 or 3, 16–22 mm long, yellow or tinged purple; pods villous along the margin. Escaped cultivated plants in Weber Co., widespread in the Pacific Coast states; introduced from Europe; 9 (0).

DALEA L.

Perennial herbs, unarmed; leaves alternate, odd-pinnate with 3 or more leaflets, glandular-dotted; stipules linear to subulate; peduncles opposite the leaves; flowers in dense spikes; calyx campanulate, 5- to 10-ribbed and 5-lobed; corolla papilionaceous, the banner petal attached near the rim of the floral cup, the other four variously inserted or all near the rim of the staminal tube; stamens 5, monadelphous; petals white, yellowish, pink, or pink-purple to indigo; pods 1- to 2-seeded, indehiscent, included in the calyx or slightly exceeding it. Note: Included herein are the herbaceous species traditionally placed in *Petalostemon*, and excluded are those shrubby species now treated as belonging to *Psorothamnus* (q.v.).

REFERENCES

WEMPLE, D. K. 1970. Revision of the genus *Petalostemon* (Leguminosae). Iowa State Jour. Sci. 45:1–102.

1. Stems prostrate; spikes slender, commonly less than 8 mm thick; leaflets 5–17; plants of Kane, San Juan, and Washington cos. .... *D. lanata*

— Stems decumbent to ascending or erect; spikes thicker, commonly 10 mm or more; leaflets 7 (9) or fewer; distribution various 2

2(1). Herbage glabrous 3

— Herbage pilose, pilosulous, or hirsute with lustrous hairs 4

3(2). Petals pink to pink-purple; calyx oblique, the teeth long-pilose; plants west of the Colorado River .... *D. searlsiae*

— Petals white (fading cream); calyx symmetric, the teeth ciliate; plants mostly east of the Colorado River (rarely to the west) .... *D. oligophylla*

4(2). Spikes dense, the longest seldom more than 5 cm long; calyx teeth 1.5–2.5 mm long; plants wide-spread in Kane, San Juan, Grand, Emery, Wayne, and Garfield cos. .... *D. flavescens*

— Spikes rather lax, the longest 5–14 cm long; calyx teeth 2.7–4 mm long; plants of San Juan Co. .... *D. epica*

Dalea epica **Welsh.** Hole-in-the-Rock Prairie-clover. Stems ascending to erect, 20–42 cm tall, from a superficial to subterranean woody caudex, strigulose to pilose; stipules 2–4 mm long, lance-subulate to linear, persistent; leaves 1.5–3.8 cm long; leaflets 3–5, 5–19 mm long, 2–9 mm wide, flat or folded, oblanceolate to elliptic, acute, lustrous-strigulose or -pilose, glandular beneath; terminal leaflet petiolulate on a continuation of the rachis, the rachis prolongation very short; peduncles 1.5–9 (12) cm long, sparingly villous-hirsute; spikes (2) 2.5–9 (14) cm long, 12–18 mm wide (when pressed), the rachis spreading-hairy; bracts 4–7 mm long, lance-aristate, villous; calyx 5–7 mm long, obscurely 10-ribbed, the tube not translucent, the teeth 2.7–4 mm long; flowers 7.5–11 mm long, the petals white; pistils 11.5–13 mm long, the style 8.5–9.5 mm long; pods villous. Sandstone bedrock and dunes at 1530 m in San Juan Co. (west of Clay Hills Divide); endemic. The Hole-in-the-Rock prairie-clover is a near ally of *D. flavescens*, within whose range it occurs, but with whom it is apparently allopatric; 5 (v).

Dalea flavescens **(S. Wats.) Welsh.** Kanab Prairie-clover. [Petalostemon *flavescens* S. Wats.; *Kunistera flavescens* (S. Wats.) Kuntze.]. Stems 23–52 cm tall, from a superficial caudex, glabrous to hairy (especially above); stipules 1–4 mm long, subulate, persistent; leaves 1.5–4.7 cm long; leaflets 3–7, 6–20 mm long, 1–6 mm wide, folded or flat, oblong to oblanceolate or linear, lustrous-strigulose on both surfaces, glandular beneath; terminal leaflet stalked to subsessile; peduncles 3–20 cm long, glabrous or sparsely to densely pilose-hirsute; spikes 1.5–6.5 cm long, 10–16 mm wide (when pressed), and sometimes glandular; calyx 10-ribbed, the tube not translucent, the teeth 1.5–2.5 mm long; flowers 6.2–9.5 mm long, the petals white, fading cream; pistils 7.5–10.3 mm long, the style 6–8 mm long; pods villous. Grasslands, mixed desert shrub, blackbrush, and pinyon-juniper communities, commonly in sandy soils, at 970 to 1870 m in Emery, Garfield, Grand, Kane (type from Kanab), San Juan, and Wayne cos.; Arizona, a Navajo Basin endemic. The Kanab prairie-clover is remarkably variable in several features, e.g., in number and position of glands, in vesture of the peduncle, and in width of the spike. In one specimen (Holmgren & Goddard 9990, frag. BRY) from the bottom of Glen Canyon near the mouth of Bridge (Forbidding) Canyon (now beneath Lake Powell), the calyx teeth are glandular. This seems to represent an extension of the glandular condition from bracts, where they exist or don't exist, to the calyx teeth, where they usually do not exist. Spike width varies with maturity of flowers and fruit, but there is a tendency, especially along the canyons of the Colorado River, towards very broad flowering spikes (12–16 mm), and these might warrant taxonomic recognition when more material becomes available. Plants from East Clark Bench and eastward to Last Chance Canyon in Kane Co., mainly occupy stabilized dunes dominated by *Vanclevea-Ephedra-Oryzopsis* mixtures, and have moderately to densely hairy peduncles which vary from 3–10 cm in length at anthesis. Most of the remainder of the plants in Utah have glabrous to sparingly hairy peduncles, which are 9–20 cm long at anthesis. When more specimens are at hand, it might become prudent to treat these variants at some taxonomic level; 33 (xiv).

Dalea lanata Spreng. Woolly Dalea. [*Parosella lanata* (Spreng.) Britton; *D. terminalis* (M. E. Jones) Heller]. Stems prostrate, 15–60 cm long or more, from a subterranean to superficial caudex, pilosulous to glabrous; stipules 1–2 mm long, subulate, more or less persistent; leaves 0.9–3 cm long; leaflets 5–17, 1.5–10 mm long, 1–5.5 mm wide, obovate to cuneate, truncate to emarginate, commonly folded, pilosulous or glabrous; peduncles 0.5–2.5 cm long; spikes 1.8–7.5 cm long, lax in mid- to late-anthesis and in fruit; bracts ovate-acuminate, pilosulous and with one or more large glands; calyx 3.2–4.6 mm long, the tube 2.1–2.7 mm long, glabrous, the teeth 0.9–1.9 mm long, pilosulous dorsally and ciliate; flowers 6–7 mm long, the petals indigo to rose-pink; pistils 5–6 mm long, the style 3.5–4.5 mm long; pods villous or glabrous. Stabilized dunes and other sandy sites at 970 to 1370 m in Kane, San Juan, and Washington cos.; Arizona, Colorado, and Kansas south to Mexico. Our material belongs to **var. *terminalis* (M. E. Jones) Barneby.** This variety differs from *D. lanata* var. *lanata* inter alia in the glabrous, shining, membranous calyx tube. Some plants from San Juan Co. (Harrison 12194, 12194a, 12199 BRY) are glabrous throughout, but seem not to differ otherwise; 8 (0).

Dalea oligophylla (Torr.) Shinners. Western Prairie-clover. [*Petalostemon gracilis* var. *oligophyllus* Torr. in Emory; *P. gracilis* A. Gray, not *D. gracilis* Kunth; *Kuhnistera occidentalis* A. Gray ex Heller; *P. occidentale* (A. Gray) Fern.; *K. candida* var. *occidentalis* (A. Gray) Rydb.; *P. truncatus* Rydb.; *K. oligophylla* (Torr.) Heller; *P. oligophyllus* (Torr.) Rydb.; *P. truncatus* Rydb.; *P. sonorae* Rydb.; *P. candidus* var. *oligophyllus* (Torr.) F. J. Hermann.; *D. candida* var. *oligophylla* (Torr.) Shinners]. Stems decumbent to erect, 40–90 cm tall, from a superficial caudex, glabrous; stipules 1–4.5 mm long, fragile, often coiled; leaves 1.5–5.2 cm long; leaflets 4–9, 5–27 mm long, 1–7 mm wide, oblanceolate to elliptic or oblong, truncate to emarginate, commonly folded, glabrous, glandular beneath; peduncles 1.5–15 cm long, glabrous; spikes 1–6.8 cm long, 8–12 mm thick the rachis commonly glabrous; bracts lance-acuminate, caducous; calyx strongly 10-ribbed, usually pubescent between the ribs, the tube 2.3–3 mm long, the lobes 1–1.3 mm long; pistils 9–11 mm long, the style 8–10 mm long; pods glabrous or sparingly hairy apically. Sandy drainages and crevices in rimrock in mixed desert shrub, blackbush, pinyon-juniper, and hanging garden communities at 1070 to 1830 feet in Emery, Garfield, Grand, Kane, San Juan, and Wayne cos.; Alberta east to Saskatchewan and south to Arizona, New Mexico, Texas, Mexico, and Iowa. Utah specimens of the western prairie-clover are remarkably uniform; 35 (vi).

Dalea searlsiae (A. Gray) Barneby. Searls Prairie-clover. [*Petalostemon searlsiae* A. Gray; *Kuhnistera searlsiae* (A. Gray) Kuntze]. Stems decumbent to erect, 23–65 cm tall, from a superficial caudex, glabrous; stipules 1–3 mm long, deciduous; leaves 1.4–5.2 cm long; leaflets 5–11, 3–18 mm long, 0.8–6 mm wide, oblanceolate to elliptic or almost linear, truncate to emarginate or acute, commonly involute or folded, glabrous, glandular beneath; peduncles 3.5–22 cm long, glabrous; spikes 1.6–9 (13) cm long, 8–12 mm wide, the rachis glabrous to hairy; bracts obovate to lanceolate, acuminate-aristate, deciduous; calyx 10-ribbed, the tube glabrous to moderately pilose, 2.4–2.9 mm long, the lobes 1–1.4 mm long, usually long-pilose; pistils 5–7 mm long, the style 4–5 mm long; pods villous. Sagebrush, pinyon-juniper, warm-desert shrub, or less commonly in spruce-fir communities at 1230 to 2800 m in Box Elder, Garfield, Iron, Juab, Kane, Tooele, and Washington cos.; Arizona, Nevada, and California. The Searls prairie-clover is closely allied to the ornate prairie-clover (*Petalostemon ornatum* Douglas in Hook.), whose range is contiguous to the northwest. In a broad sense, possibly *D. searlsiae* would best be included as a variety of that taxon, but its features differ in about the same order of magnitude as those used to segregate other taxa at specific levels. No attempt at combination is intended or implied herein; 26 (i).

GALEGA L.

Perennial, caulescent, from a caudex and stout taproot; leaves altenate, odd-pinnate; stipules sagittate, distinct; flowers papilionaceous, borne in axillary racemes, each subtended by a bract; bracteoles 0; calyx 5-toothed; petals 5, purplish-blue, the keel subequal to the wings, attenuate apically; stamens monadelphous; ovary enclosed in the staminal sheath, the style glabrous; pods sessile, narrowly oblong in outline, more or less constricted between the seeds, unilocular.

Galega officinalis **L.** Goatsrue. Perennial, caulescent, 50–100 cm tall, from a branching caudex; pubescence basifixed; stems erect or ascending; stipules 7–16 mm long, sagittate, the basal lobes again once or twice lobed; leaves 3–22 cm long; leaflets 9–15, 7–52 mm long, 3–17 mm wide, lanceolate to elliptic, cuspidate-aristate apically, glabrous above, thinly pilose along veins beneath; peduncles 3–9 cm long; racemes 20- to 36-flowered, the flowers declined at anthesis, the axis 2.5–7 cm long in fruit; bracts 3.5–6 mm long, some commonly semi-sagittate; calyx 4–5.5 mm long, the tube 2–2.5 mm long, campanulate, glabrous, the teeth 2–3.2 mm long, subulate; flowers 9.5–12.5 mm long, blue-purple (fading cream); pods ascending, subcylindric, 18–38 mm long, 2–3 mm thick, longitudinally nerved, glabrous, unilocular. Introduced, established weedy plant, known in Utah only from Cache Co., where it has grown continuously since at least 1909; adventive from Europe; 4 (0).

GLEDITSIA L.

Trees, often armed with simple or branched thorns; leaves alternate, deciduous, pinnately once to twice compound (with both kinds of leaves often on the same branch, or some intermediate); stipules minute, caducous; leaflets 14–36 on once-pinnate leaves and on the 3–5 pinnae; flowers in spike-like axillary racemes, polygamous, almost regular; sepals equal or nearly so; petals 3–5, very narrow, yellowish, the uppermost internal in bud; stamens 3–10, distinct, the anthers in pistillate flowers abortive; pods flattened, strap-like, indehiscent.

Gleditsia triacanthos **L.** Honey Locust. Trees to 20 m tall or more; bark smooth; leaflets 12–35 cm long, the pinnae 3–5 (8) when bipinnately compound, the leaflets 14–36 on once pinnately compound leaves and on pinnae, 10–42 mm long, 3–14 mm wide, lanceolate to oblong, crenate, obtuse to cuspidate, glabrous above, puberulent along veins beneath; racemes many-flowered, 3–7 cm long, short pedunculate or subsessile; sepals separate; petals 4–5 mm long, greenish; pods sessile, oblong in outline, laterally flattened, 70–350 mm long, 15–30 mm wide, curved, indehiscent, the seeds imbedded in tissue. Cultivated shade tree, rarely escaping, in Grand, Millard, Salt Lake, Utah, and Wayne cos., and likely throughout the state at lower elevations; introduced from the eastern United States. Many horticultural forms, mainly thornless, are cultivated. The trees are handsome ornamentals, even with thorns; 15 (iii).

GLYCYRRHIZA L.

Perennial, caulescent, from stout sweet roots; leaves alternate, odd-pinnate, glandular-punctate; stipules subulate, distinct; flowers papilionaceous, in axillary racemes, each subtended by a lanceolate, deciduous bract; bracteoles 0; calyx 5-toothed; petals 5, white to cream, the keel shorter than the wings; stamens 10, diadelphous; ovary enclosed in the staminal sheath, the style glabrous; pods sessile, elliptic to oblong in outline, bur-like, armed with uncinate appendages, indehiscent, few-seeded.

Glycyrrhiza lepidota **Pursh.** Licorice. Plants 40–120 cm tall, from a deep-seated root; stipules 2–7 mm long, subulate; leaves 8–19 cm long; leaflets 13–19, 8–53 mm long, 3–15 mm wide, lanceolate to oblong, mucronate, glabrous above, glandular-dotted and puberulent beneath; peduncles often paired, 3–8 cm long; racemes 20- to 50-flowered, the flowers ascending at anthesis, the rachis, 2.5–9 cm long in fruit; bracts 5–8 mm long, caducous; calyx 4.8–6.9 mm long, the tube 2.5–4.9 mm long, campanulate to short-cylindric, stipitate-glandular, the teeth 1.5–3.6 mm long; flowers 9.1–13 mm long, white to cream; pods spreading, laterally compressed, oblong, 13–20 mm long, the body 5–7 mm wide, beset with hooked prickles, simulating cockleburs. Terraces, streamsides, seeps, and other semi-moist sites in streamside, greasewood, mixed desert shrub, and pinyon-juniper communities at 670 to 2470 m in Beaver, Cache, Daggett, Garfield, Grand, Kane, Millard, Piute, Rich, Salt Lake, San Juan, Sevier, Summit, Uintah, Washington, Wayne , and Weber cos.; widespread in the United States, except for the southeast; 53 (xii).

GYMNOCLADUS L.

Unarmed trees; leaves alternate, deciduous, bipinnately compound; stipules small, deciduous; leaflets 9–15 on each of the 3–7 pinnae, or the lowermost pinnae represented by leaflets; flowers in terminal panicles, dioecious or polygamous, regular or nearly so; calyx 5-lobed; petals 5, distinct; pods broad-oblong, hard, thick, flattened, pulpy.

Gymnocladus dioica **(L.) K. Koch.** Kentucky Coffee-tree. [*Guilandina dioica* L.; *Gymnocladus canadensis* Lam.]. Tree to 20 m or more; leaves 20–60 (90) cm long; pinnae 3–7 pair, each with 9–15 leaflets, these 17–70 mm long, 7–30 mm wide, ovate to lanceolate, entire, acuminate, pilose (especially along the veins) beneath, glabrous to glabrate above; panicles many-flowered; pistillate panicles to 25 cm long, the staminate much smaller and more dense; flowers 10–13 mm long, greenish white; fruit 100 to 200 mm long; 30–50 mm wide, persistent, tardily dehiscent, the large seeds imbedded in tissue. Cultivated ornamental and botanical curiosity in Salt Lake and Utah cos., and probably elsewhere; introduced from the eastern United States. The Kentucky coffee-tree is so named because the pulp surrounding the seeds is rich in a polysaccharide which, when roasted, has been used as a coffee substitute; 4 (i).

HEDYSARUM L.

Perennial herbs, caulescent, from a caudex and taproot; leaves alternate, odd-pinnate, stipules adnate to the petiole base, at least the lowermost connate-sheathing; flowers papilionaceous, in axillary racemes, each subtended by a bract; bracteoles 2; calyx 5-toothed; petals 5, red-purple to pink or pink-purple, the keel much longer than the wings, abruptly bow-shaped; stamens 10, diadelphous; ovary enclosed in the staminal sheath, the style glabrous; loments with 2–8 segments, prominently reticulate.

REFERENCES

NORTHSTROM, T. E. 1974. The genus *Hedysarum* in North America. Ph.D. Dissertation. Brigham Young University. 187 pp.

NORTHSTROM, T. E. AND S. L. WELSH. 1970. Revision of the *Hedysarum boreale* complex. Great Basin Nat. 30:109–130.

ROLLINS, R. C. 1940. Studies in the genus *Hedysarum* in North America. Rhodora 42:217–238.

1. Leaflets thin, the veins readily apparent; fruit segments winged; calyx lobes unequal, shorter than the tube; plants rare in eastern Utah .... *H. occidentale*

— Leaflets thick the veins not apparent; fruit segments not winged; calyx lobes subequal, longer than the tube; plants common, widespread .... *H. boreale*

Hedysarum boreale **Nutt.** Northern Sweetvetch. Perennial, caulescent, 17–70 cm tall, from branching subterranean to superficial caudex; pubescence basifixed; stems decumbent to erect; stipules 2–10 mm long, at least some connate-sheathing; leaves 3–12 cm long; leaflets 5–15, 7–35 mm long, 2–19 mm wide, oblong to elliptic, lance-oblong, or ovate (rarely linear), strigose on both sides or glabrate to glabrous above; peduncles 2.8–15 cm long; racemes 5- to 45-flowered, the flowers ascending at anthesis, the axis 5–28.5 cm long in fruit; bracts 2–5 mm long; pedicels 0.8–4.5 mm long; bracteoles 2; calyx 4.5–8 mm long, the tube 2.5–3.5 mm long, campanulate, strigose, the teeth 2–6 mm long, subulate; flowers 10–19 mm long, red-purple to pink or pink-purple, less commonly white; loments stipitate, pendulous to spreading, with 2–8 segments, not winged, prominently reticulate. Our material belongs to ssp. *boreale* and is separable into two varieties.

1. Segments of the loment bearing spines on the lateral surfaces; plants of Uintah Co. .... *H. boreale* var. *gremiale*

— Segments of the loment lacking spines; plants widespread .... *H. boreale* var. *boreale*

Var. *boreale*. [*H. carnulosum* Greene; *H. pabulare* A. Nels; *H. utahense* Rydb.; *H. pabulare* var. *rivulare* L. O. Williams; *H. mackenziei* var. *pabulare* (A. Nels.) Kearney & Peebles; *H. utahense* Rydb., type from Salt Lake City; *H. boreale* var. *utahense* (Rydb.) Rollins; *H. canescens* Nutt. ex Torr. & Gray; *H. cinerascens* Rydb.; *H. mackenziei* var. *canescens* (Nutt.) Fedtsch.; *H. boreale* var. *cinerascens* (Rydb.) Rollins; *H. boreale* var. *obovatum* Rollins]. Mixed desert shrub, pinyon-juniper, mountain brush, ponderosa pine, and aspen communities at 1175–2500 m in Box Elder, Cache, Carbon, Davis, Duchesne, Emery, Garfield, Grand, Juab, Millard, Salt Lake, San Juan, Sanpete, Sevier, Tooele, Uintah, Utah, Wasatch, Washington, Wayne, and Weber cos.; Alberta east to Manitoba and south to Nevada, Arizona, New Mexico, and Texas. The use of leaf pubescence, or lack thereof, to segregate the var. *boreale* into further taxa is a function in frustration, leading to two essentially sympatric phases which might reflect ecology more than genetics; 142 (xxiv).

Var. *gremiale* (Rollins) Northstrom & Welsh. [*H. gremiale* Rollins]. Pinyon-juniper and mountain brush communities at 1470 to 1670 m in Uintah Co.; endemic. The spines on the loment segments vary from few (or none) to numerous, indicating complete transition with var. *boreale*. Incipient spines are found in specimens of var. *boreale* from outside of Utah, but nowhere are the spines so well or so consistently developed as in Uintah Co.; 3 (0).

***Hedysarum occidentale* Greene.** Western Sweetvetch. [*H. lancifolium* Rydb.; *H. marginatum* Greene; *H. uintahense* A. Nels.]. Perennial, caulescent, 30–90 cm tall, from a branching, superficial caudex; pubescence basifixed; stems ascending to erect; stipules 10–17 mm long, at least some connate-sheathing; leaves 8–20 cm long; leaflets 11–19, 9–37 mm long, 4–16 mm wide, ovate to lance-ovate or elliptic, apiculate to emarginate, strigose on both sides or glabrous above; peduncles 3.7–15 cm long; racemes 10- to 50-flowered, the flowers spreading to declined at anthesis, the axis 6–14 cm long in fruit; bracts 2–8 mm long; bracteoles 2; calyx 3.5–11 mm long, the tube 2.3–6 mm long, campanulate, glabrous to strigose, the teeth 0.5–2 mm long, triangular; flowers 16–23 mm long, pink to red-purple; loments stipitate, pendulous, with 1–5 segments, winged. Mountain brush, sagebrush, and lower spruce-fir-aspen communities at 1770 to 2430 m in Carbon, Duchesne, Emery, and Summit cos.; British Columbia south of Washington, Montana, Idaho, Wyoming, and Colorado. Utah plants have been collected in flower and fruit in mid-to late summer; 8 (vi). Material from Carbon and Emery counties differs from the main body of the species in leaflet features and is separable as **var. *canone* Welsh var. nov.** *Hedysaro occidentali* var. *occidentali* aemulans sed foliolis ovatis ellipticis vel late lanceolatis et apice retusis truncatis vel apiculatis. Holotype: Utah; Carbon Co. 14 mi due ENE of Helper, Soldier Creek, 7408 feet, Welsh & Taylor 15256, 30 June 1977 (BRY). Paratypes: Carbon Co., Soldier Canyon, Welsh & Christensen 6614, 11 August 1967; 2.5 mi due N. of Sunnyside, Welsh & Taylor 15075, 21 June 1977; east of Sunnyside, Welsh & Murdock 9146, 19 July 1969, do, Welsh & Christensen 6598, 11 Aug 1967. Emery Co., 9 mi due NNE of Wood-side, Welsh 14923, 9 June 1977 (all BRY).

HOFFMANSEGGIA Cavanilles

Perennial herbs, rhizomatous (?) and with a subterranean caudex; leaves alternate, bipinnately compound, odd-pinnate as to pinnae and even-pinnate as to leaflets, the leaflets not glandular punctate; stipules distinct, persistent; flowers in terminal racemes, perfect, irregular; calyx 5-lobed; petals 5, yellow, the uppermost internal in bud; stamens 10, the filaments distinct; pods oblong or falcate in outline, laterally compressed, indehiscent.

Hoffmanseggia repens **(Eastwood) Cockerell.** Creeping Rush-pea. [*Caesalpinia repens* Eastwood; *Moparia repens* (Eastwood) Britton]. Subacaulescent or shortly caulescent, 5–12.5 cm tall (above ground), from a deeply subterranean caudex, the branches below ground 3–15 cm long, pale; pubescence basifixed; leaves 2.5–9.5 cm long; pinnae 3–7 (9); leaflets 4–14, 3–12 mm long, 1–6 mm wide, asymmetrically obovate-elliptic to oblong, crowded, entire, villosulous; peduncles 1.2–6 cm long; racemes 7- to 26-flowered, the flowers spreading at anthesis, the axis 3–8 cm long in fruit; bracts 3–7 mm long, caducous; bracteoles 0; pedicels 2–7 mm long; calyx 8–10.5 mm long, the tube 2–4.5 mm long, campanulate, retrorsely villosulous, the teeth 6–8.5 mm long, oblong-lanceolate, villosulous; flowers opening flat or nearly so, the petals yellow, 10–12 mm long, red-spotted near the base, the whole fading pink-orange; pods pendulous, oblong, 20–50 mm long, 10–20 mm wide, membranous, pilosulous. Sandy deserts with *Ephedra*, *Oryzopsis*, and other arenophilus plants at 1430 to 1670 m in Emery, Garfield, Grand (type from Court House Wash), and Wayne cos.; endemic. This is a striking plant in the light of early morning along the sandy stretches near Hanksville; 20 (iv).

LABURNUM Medic.

Trees, unarmed; leaves alternate, palmately trifoliolate; stipules lacking; flowers in terminal, pendulous racemes, perfect; calyx 2-lipped, the upper lip 2-toothed, the lower lip with 3 coalescent teeth; petals all distinct; stamens 10, monadelphous; ovary stipitate; pods pendulous with the raceme, narrowly oblong, laterally compressed, more or less constricted between the few to several seeds.

Laburnum anagyroides **Medic.** Goldenchain, Bean-tree. [*L. vulgare* Bercht. & Presl.; *Cytissus laburnum* L.]. Slender trees to 6 m tall; leaves (including petioles) 1.7 cm long 2.5–15 cm long; leaflets 3, palmate, 1.4–7.5 cm long, 0.7–3.5 cm wide, lanceolate to elliptic or oblanceolate, acute to obtuse or rounded, strigulose to glabrate beneath, glabrous above, often ciliate; peduncles 1.2–3.8 cm long; racemes (7) 15- to 50-flowered, the flowers inverted and spreading at anthesis, the axis 15–30 cm long in fruit; bracts lacking; bracteoles 0; pedicels 8–14 mm long; calyx oblique, 4.5–5.5 mm long, the tube 3–4 mm long, glabrous, the lobes about 1.5 mm long, tufted hairy; flowers 14–17 mm long, yellow; pods stipitate, the stipe 2–5 mm long, the body oblong in outline, 30–50 mm long, 5–8 mm wide, strigose, tardily dehiscent. Cultivated ornamental trees of great beauty, in population centers, in much of Utah; introduced from southern Europe; 4 (0).

LATHYRUS L.

Annual or perennial herbs, clambering, trailing, or climbing; leaves alternate, even-pinnately compound, the rachis terminating in a bristle or prehensile tendril; stipules herbaceous, semi-hastate or semi-sagittate; leaflets 2–12, very variable; flowers in axillary racemes, papilionaceous; calyx 5-toothed, obliquely campanulate; petals 5, white or cream to pink, purplish, or otherwise (in cultivated types), the wings not adnate to the keel, but fitted together in a groove; stamens 10, diadelphous; style laterally compressed, bearded along the ventral (upper) edge; pods oblong, several-seeded, the valves coiling upon dehiscence.

REFERENCES

HITCHCOCK, C. L. 1952. A revision of the North American species of *Lathyrus*. Univ. Wash. Publ. Biol. 15:1–104.

WELSH, S. L. 1965. Legumes of Utah III: *Lathyrus* L. Proc. Utah Acad. Sci. 42:214–221.

1. Leaflets 2; stems winged; plants introduced, annual or perennial 2

— Leaflets 4 or more; stems angled but not winged; plants indigenous, perennial 4

2(1). Plants annual, pubescent; flowers 25–30 mm long .... *L. odoratus*

— Plants perennial, glabrous; flowers 12–25 mm long 3

3(1). Leaflets narrowly lanceolate to elliptic; flowers 15–18 mm long .... *L. sylvestris*

— Leaflets lance-elliptic to oblong or ovate; flowers 20–25 mm long .... *L. latifolius*

4(1). Keel conspicuously shorter than the wings; calyx glabrous or the teeth merely ciliate, the lower tooth usually longer than the tube; stipules large, foliaceous; petals pink-purple, rarely white .... *L. pauciflorus*

— Keel commonly subequal to the wings; calyx often hairy, the lower tooth shorter than the tube; stipules not foliaceous; flowers pink-purple, pale lavender, pinkish-violet, cream, or white 5

5(4). Flowers 8–16 mm long; petals pale lavender-tinged to pinkish-violet, cream, or white, often polychrome in populations; plants common at middle elevations, especially in aspen, flowering in summer .... *L. lanzwertii*

— Flowers 15–30 mm long; petals bright pink- to blue-purple; plants widespread at lower elevations, flowering mainly in springtime .... *L. brachycalyx*

Lathyrus brachycalyx **Rydb.** Redberg Sweetpea. Perennial clambering herbs, decumbent to erect, 10–50 cm long, the herbage villous to glabrous; stipules 6–15 mm long, semi-sagittate; leaves 2–9 cm long (excluding tendrils); leaflets 6–12, 5–50 (70) mm long, 2–15 mm wide, linear to elliptic, oblong lanceolate, or oblanceolate; tendrils simple or branched; peduncles 4–10 cm long; racemes 2- to 5-flowered, the flowers spreading at anthesis; calyx tube 3.5–7 mm long, campanulate, the teeth 1.5–6 mm long, triangular to lanceolate; flowers 15–30 mm long, pink to pink-purple; pods 30–70 mm long, 5–10 mm wide. There are three more or less distinctive and allopatric varieties in Utah.

1. Plants villous; leaflets commonly 10–25 cm long; flowers 18–25 mm long; banner not deeply cordate apically, the blade as long as broad; calyx tube 3.5–5.5 mm long, the teeth 2.2–3.8 mm long; Great Basin .... *L. brachycalyx* var. *brachycalyx*

— Plants glabrous or sparingly villous; leaflets commonly 25–70 mm long; flowers, banner and calyx various; mainly not of the Great Basin 2

2(1). Flowers 15–25 mm long; banner often deeply cordate, the blade commonly broader than long; calyx tube 4–5 mm long, the teeth 1.5–2.3 mm long .... *L. brachycalyx* var. *zionis*

— Flowers 20–30 mm long; banner but shallowly retuse, the blade much longer than broad; calyx tube 5–7 mm long, the teeth 2–5 mm long .... *L. brachycalyx* var. *eucosmus*

Var. *brachycalyx*. [*L. brachycalyx* Rydb., type from City Creek Canyon]. Mixed desert shrub, pinyon-juniper, and mountain brush communities at 1575 to 2600 m in Beaver, Box Elder, Juab, Millard, Salt Lake, Sanpete, Tooele, and Utah cos.; Nevada (?), a Great Basin endemic; 51 (vi).

Var. *eucosmus* **(Butters & St. John)**

Welsh stat. nov. based on *Lathyrus eucosmus* Butters & St. John Rhodora 19:160. 1917. [*L. brachycalyx* ssp. *eucosmus* (Butters & St. John) Welsh.] Clay soil in washes in salt desert shrub communities at 1450 to 1700 m in Emery, Grand, and Sanpete cos.; Colorado, New Mexico, and Arizona; 5 (0).

Var. *zionis* (C. L. Hitchc.) Welsh stat. nov. based on *Lathyrus zionis* C. L. Hitchc., Univ. Wash. Publ. Biol. 15:36. 1952. [*L. brachycalyx* ssp. *zionis* (C. L. Hitchc.) Welsh.] Sandy soils in pinyon-juniper, mixed desert shrub, and riparian communities at 1200 to 2500 m in Garfield, Grand, Kane, San Juan, and Washington cos.; Arizona; 42 (vi).

***Lathyrus lanzwertii* Kellogg.** Lanzwert Sweetpea. Plants clambering, decumbent to erect, 20–60 cm tall, the herbage glabrous to villous; stipules 7–20 mm long, semi-sagittate; leaves 2–14 cm long (excluding tendrils) leaflets 4–12, 7–75 mm long, 3–18 (26) mm wide, elliptic to lanceolate, oblanceolate, or oval; tendrils short and simple to more commonly branched and prehensile; peduncles 2–8.5 cm long; racemes 2- to 5-flowered, the flowers spreading at anthesis; calyx tube 3.5–6 mm long, campanulate, the lower lateral teeth 1.8–4.2 mm long, triangular to lanceolate; flowers 12–22 mm long, pink-purple to white or cream and commonly suffused or veined with pink or purple; pods 30–60 mm long, 3–7 mm wide. Three rather poorly defined and apparently intergrading varieties are present in Utah. The following arbitrary key will allow segregation of most of the specimens.

1. Tendrils reduced to a simple filiform stalk, rarely coiled; leaflets commonly 6 only; plants rare in southern Utah .... *L. lanzwertii* var. *arizonicus*

— Tendrils commonly branched and/or coiled; leaflets often more than 6; plants widespread 2

2(1). Flowers white, less commonly suffused or veined with pink or purple, mostly 15–22 mm long; plants more abundant southward in Utah .... *L. lanzwertii* var. *laetivirens*

— Flowers pink-purple or suffused with purple, commonly 12–17 mm long; plants more abundant northward in Utah .... *L. lanzwertii* var. *lanzwertii*

Var. *arizonicus* (Britton) Welsh. comb. nov. based on *L. arizonicus* Britton Trans. N. Y. Aca. Sci. 8:65. 1899. Aspen and mountain brush communities at 2470 to 2770 m in San Juan Co.; Arizona; 4 (0).

Var. *laetivirens* (Green) Welsh stat. nov. based on *Lathyrus laetivirens* Greene ex Rydb. Fl. Colorado 2.7. 1906. [*L. leucanthus* Rydb.; *L. leucanthus* var. *laetivirens* (Greene) C. L. Hitchc.] Riparian, aspen, mountain brush, coniferous woods, and other montane communities, at 1830 to 3130 m in Beaver, Carbon, Emery, Garfield, Grand, Millard, Salt Lake, San Juan, Sanpete, Sevier, and Washington cos.; Colorado. 32 (x).

Var. *lanzwertii*. [*L. coriaceus* White, type from Wasatch Mts.]. Aspen, Douglas fir, spruce fir, and less commonly in mountain brush communities at 1650 to 2400 m in Davis, Duchesne, Garfield, Rich, Tooele, Salt Lake, Sanpete, Sevier, Summit, Utah, and Wasatch cos.; Washington, Oregon, California, Idaho, and Nevada; 54 (xxii).

***Lathyrus latifolius* L.** Perennial Sweetpea. Perennial, climbing vines, 80–200 cm tall, the stems broadly winged, glabrous; stipules 9–40 mm long, semi-hastate to semi-sagittate; leaves 6–12 cm long (excluding tendrils; leaflets 2, 35–80 (150) mm long, 5–23 (50) mm wide, lance-elliptic to oblong or ovate; tendrils branched, coiled; peduncles 7–15 cm long; racemes 5- to 15-flowered, the flowers spreading at anthesis; calyx tube 5.8–6.2 mm long, campanulate, the lower lateral calyx teeth 3–6 mm long, lanceolate; flowers 20–25 mm long, pink-purple, pink or white; pods 60–80 mm long, 7–10 mm wide, glabrous. Cultivated, escaping and now established, mainly along canal banks in Carbon, Grand, and Utah cos., and probably widespread; introduced from Europe; 4 (ii).

***Lathyrus odoratus* L.** Sweetpea. Annual, climbing vines, 80–300 cm tall, the stems broadly winged, pubescent; stipules 10–30 mm long, semi-hastate; leaves 6–15 cm long (excluding tendrils); leaflets 2, 25–85 mm long, 8–40 wide, elliptic to ovate or oblanceolate; tendrils well-developed, prehensile; peduncles 3–28 cm long; racemes 2- to 5-flowered, the flowers spreading at anthesis; calyx tubes 5.5–7.5 mm long, campanulate, spreading-hairy, the lower lateral teeth 5–8 mm long, lanceolate; flowers 25–37 mm long, varicolored; pods 30–60 mm long, 5–8 mm wide, pubescent. Cultivated ornamental or greenhouse and outside plantings, growing best in cool middle elevations of the state; introduced from Europe; 2 (ii).

***Lathyrus pauciflorus* Fern.** Utah Sweetpea. [*L. utahensis* M. E. Jones; *L. pauciflorus* var. *utahensis* (M. E. Jones) Peck; *L. bradfieldianus* A. Nels.]. Perennial, 20–100 cm tall or more, climbing vines, glabrous; stems merely angled; stipules 8–32 mm long, the larger ones, at least, foliose and toothed; leaves 2–12.5 cm long (excluding tendrils); leaflets 8–12, 14–50 mm long, 8–32 mm wide, ovate to elliptic; tendrils well-developed, prehensile; peduncles 3.5–24 cm long; racemes 3- to 10-flowered, the flowers spreading at anthesis; calyx tube 5–7.3 mm long, obliquely campanulate, more or less gibbous, the lower lateral teeth 2.5–7 mm long, often curved and spreading; flowers (13) 15–23 (27) mm long, pink to pink-purple, with keel usually pale or white; pods 40–75 mm long, 7–11 mm wide. Oak-sagebrush, mountain brush, aspen, lodgepole pine, mixed conifer, and meadow communities at 1370 to 2900 m in Box Elder, Cache, Davis, Millard, Salt Lake, Sanpete, Sevier, Summit, Tooele, Utah, Wasatch, and Weber cos.; Washington, Oregon, Idaho, Colorado, and Arizona. The Utah sweetpea forms apparent hybrids with *L. lanzwertii*. Leaf and flower features are intermediate in such plants (e.g., Higgins 1048; Clark 2008; Welsh & Isely 6378, all BRY); 71 (x).

***Lathyrus sylvestris* L.** Scots Sweetpea. Perennial, 60–200 cm tall, clambering, the stems broadly winged, glabrous; stipules 20–34 mm long, semi-sagittate; leaves 3–12 (15) cm long (excluding tendrils); leaflets 2, 30–120 mm long, 5–40 mm wide, linear-lanceolate to lanceolate or elliptic; peduncles 8–22 cm long; racemes 4- to 9-flowered, the flowers ascending-spreading at anthesis; calyx tube 4–5 mm long, campanulate, the lower lateral teeth 1.7–4 mm long, lanceolate; flowers 15–18 mm long, red or red-purple; pods 40–60 mm long, 5–8 mm wide, glabrous. Cultivated ornamental, persisting, escaping, and established in Utah Co., and probably elsewhere; introduced from Europe. 2 (0).

LESPEDEZA Michx.

Perennial herbs (or woody at the base), from a caudex; leaves alternate, pinnately trifoliolate; stipules inconspicuous; flowers papilionaceous, in axillary racemes or subpaniculate, each subtended by a bract; bracteoles 2, attached at base of calyx; calyx 5-toothed; petals 5, pink-purple; stamens 10, diadelphous; ovary 1-ovuled, the style incurved and beardless, the stigma small and terminal; pod short, partially included in the calyx.

***Lespedeza thunbergii* (DC.) Nakai.** Thunbery Bush Clover. [*Desmodium thunbergii* DC.]. Perennial, 80–100 cm tall or more and 150–200 cm wide, clump-forming; pubescence basifixed; stems striate; petioles 0.3–0.8 cm long; leaflets 3, lacking stipules, commonly 20–50 mm long, elliptic to oblong, glabrous above, strigose beneath; peduncles 0.5–1.2 cm long; racemes many-flowered; flowers 10–12 mm long (or more?), pink-purple; bracteoles lanceolate; pods obovate to oblong, to 10 mm long. Cultivated ornamental plant in Utah Co.; introduced from China.

LOTUS L.

Plants annual or perennial herbs or suffrutescent, caulescent, from a taproot and caudex; leaves alternate, pinnately (or appearing palmately) compound; stipules foliaceous, scarious, or gland-like; flowers papilionaceous, in axillary pedunculate umbels or solitary; bracts leaf-like; calyx 5-toothed; petals 5, yellow or white, sometimes suffused with red, the keel long-attenuate; stamens 10, diadelphous; ovary enclosed in the staminal sheath, the style glabrous; pods flattened or subterete, straight, one to several-seeded, dehiscent.

REFERENCE

OTTLEY, A. M. 1944. The American Loti with special consideration of a proposed new section, Simpeteria. Brittonia 5:81–123.

1. Plants annual, prostrate to ascending; flowers sessile in leaf axils; plants of Washington Co. 2

— Plants perennial, sometimes flowering the first year, prostrate to erect 3

2(1). Plants subglabrous or merely strigose; calyx teeth subequal to the tube; pods 10–15 mm long .... *L. subpinnatus*

— Plants villous; calyx teeth much longer than the tube; pods 5–10 mm long .... *L. humistratus*

3(1). Flowers sessile, solitary in leaf axils, or on peduncles to 2.6 cm long; plants indigenous in San Juan Co. .... *L. wrightii*

— Flowers pedunculate, solitary or 2 to several; plants variously distributed, not or seldom of San Juan Co. 4

4(3). Plants suffruticose, rigid, commonly erect, internodes greatly exceeding leaf length; bracts of inflorescence 1 or 0; plants of Washington Co. .... *L. rigidus*

— Plants herbaceous, prostrate to ascending or erect; internode and leaf length various; bracts of inflorescence 1 or more; distribution various 5

5(4). Stipules leaflet-like; plants introduced, cultivated and escaping 6

— Stipules reduced to glands; plants indigenous 7

6(5). Flowers 3 or 4, 7–9; leaflets of main leaves lance-linear to narrowly elliptic, acute .... *L. tenuis*

— Flowers 5–12, 8–12 mm long; leaflets of main leaves obovate, rounded .... *L. corniculatus*

7(5). Leaves sessile, the leaflets strictly palmate, usually drying a lead-green color; plants widely distributed in central to southwestern Utah .... *L. utahensis*

— Leaves short-petiolate, the rachis elongate and at least one leaflet pinnately disposed; plants of western Kane, Washington, and Iron cos. .... *L. longebracteatus*

Lotus corniculatus L. Bird's-foot Trefoil. Perennial, 10–50 cm long, with ascending or procumbent stems, glabrous or strigose; stipules foliar, almost or quite as large as the leaflets; leaflets 3, 5–15 mm long, 2–8 mm wide, obovate, rounded apically; peduncles 0.5–7.5 cm long; bracts 1- to 3-foliolate; flowers (1 or 2) mostly 5–12, 8–12 mm long, yellow; calyx 3–4 mm long, the teeth subequal to the tube; pods linear 20–35 mm long, 2–3.5 mm thick, subterete, straight, glabrous. Cultivated forage plant of moist pastures, persisting in Cache, Millard, Utah, and Washington cos., and to be expected elsewhere; introduced from Europe; 2 (0).

Lotus humistratus Greene. Low Trefoil. Annual, 6–30 cm long, with prostrate to ascending stems; stipules reduced to glands; leaves pinnate, the rachis flattened; leaflets 3–5, 3–15 mm long, 1–8 mm wide, obovate to oblanceolate, obtuse apically; peduncles 0, the flowers solitary, axillary, 4–6 mm long, yellow or tinged red; calyx 3–4 mm long, the teeth much longer than the tube; pods 5–10 mm long, 2.5–3.5 mm wide, laterally compressed, strigulose-villous. Sandy or gravelly sites in creosote bush and warm desert shrub communities at 670 to 800 m in Washington Co.; Arizona, New Mexico, and California; Mexico; 4 (0).

Lotus longebracteatus **Rydb.** Long-bracted Trefoil. [*Anisolotus longebracteatus* (Rydb.) Rydb.; *Hosackia rigida* var. *numularia* M. E. Jones; *Anisolotus numularius* (M. E. Jones) Woot. & Standl.; *L. numularius* (M. E. Jones) Tidestr., not Reichb. ex Steud.; *L. numulus* Drayton; *L. rigidus* x *utahensis* Ottley]. Perennial, 7–38 cm long, with prostrate to decumbent stems radiating from a herbaceous, superficial caudex; stipules reduced to glands; leaves petiolate, pinnate, with at least one leaf commonly placed along the short rachis; leaflets 3 or 4, 2–22 mm long, 1–8 mm wide, oblanceolate to elliptic or oval (on lowermost leaves), obtuse to acute; peduncles 0.5–6.5 cm long; bracts 1- to 3-foliolate; flowers 1 or 2, 12–17 mm long, yellow, suffused with red; calyx 5–8 mm long, the tube 2.8–5.1 mm long, strigose, the teeth 2.2–3.9 mm long, shorter than the tube; pods narrowly oblong, 15–28 mm long, 3–4 mm wide, straight, strigose. Sandy and gravelly sites in desert shrub, riparian, and pinyon-juniper communities at 670 to 1600 m in Iron, Kane (west of the Paria River), and Washington cos.; Nevada and Arizona. Plants of long-bracted trefoil were considered by Ottley (1944: 109–113) to be hybrids between *L. rigidus* and *L. utahensis*. Specimens from Utah, even those annotated by Ottley, do not support that interpretation. They are not intermediate between the putative parents. Rather, the plants have features not shared by either *L. utahensis* or *L. rigidus*. Both of these taxa have erect or ascending stems from ligneous to subligneous superficial to subterranean caudices. The stems of *L. longebracteatus* are prostrate-decumbent or procumbent from a herbaceous caudex, a feature evidently overlooked by Ottley, and not shared by either of the purported parents. Other more subtle characteristics differ also (see descriptions); 42 (vi).

Lotus rigidus **(Benth.) Greene.** Bush Trefoil. [*Hosackia rigida* Benth.; *Anisolotus rigidus* Rydb.; *L. argensis* Coville]. Perennial, 25–70 cm tall, with erect or ascending stems commonly woody at the base, from a ligneous or subligneous, superficial caudex; stipules reduced to glands; leaves petiolate, the rachis flattened, pinnate, with at least one leaflet along the rachis; leaflets 3–5, 2–20 mm long, 0.8–4 mm wide, oblanceolate to oblong, obtuse to emarginate; peduncles 2.3–14 cm long; bracts 1- to 3-foliolate; flowers 1–3, 12–23 mm long, yellow suffused with red; calyx 6.2–10 mm long, the tube 4.2–6.5 mm long, cylindro-campanulate, strigose, the teeth 2–4 mm long, shorter than the tube; pods narrowly oblong, 32–45 mm long, 3.7–4.2 mm wide, straight, glabrous. Sandstone outcrops and sandy to clay banks and terraces at 800 to 1070 m in Washington Co.; Nevada, Arizona, California, and Mexico. The bush trefoil is a remarkable plant, forming rounded clumps of very brittle stems, making difficult the task of representing it well on herbarium mounts; 11 (iii).

Lotus subpinnatus **Lag.** Mohave Trefoil. [*Hosackia subpinnata* (Lag.) Torr. & Gray; *L. wrangelianus* Fischer & Meter]. Annual, 3–30 cm long, with prostrate to ascending stems, glabrous to strigose; stipules reduced to glands; leaves pinnate, the rachis flattened; leaflets 3–5, 1.5–15 mm long, 0.8–7 (10) mm wide, obovate, obtuse to truncate apically; peduncles 0, the flowers solitary, axillary, 4.5–7 mm long, yellow or suffused red; calyx 2.8–5 mm long, the teeth subequal to the tube; pods 10–15 mm long, 2.8–3.1 mm wide, compressed, sparingly strigose. Salt desert shrub and warm desert shrub communities at 870 to 1100 m in Washington Co.; Nevada and California; 4 (0).

Lotus tenuis **Kit. in Willd.** Slender Trefoil. [*L. corniculatus β tenuifolius* L.; *L. tenuifolius* (L.) Reichb.]. Perennial, 20–60 cm long, with weak, ascending stems, glabrous; stipules foliar, almost or quite as large as the leaflets; leaflets 3, 5–15 mm long, 2–4 mm wide, lanceolate to narrowly oblanceolate or lance-linear, acute apically; peduncles 2–7.5 cm long; bracts 1- to 3-foliolate; flowers 2–4, 7–9 mm long, yellow (often drying blue); calyx 4–5 mm long, the teeth subequal to the tube; pods linear, 25–30 mm long, 2–3 mm thick, subterete, straight, glabrous. Cultivated forage plant of moist meadows, persisting in Utah Co., and probably elsewhere; introduced from Europe; 1 (0).

Lotus utahensis **Ottley.** Utah Trefoil. Perennial, 15–43 cm tall, with erect-ascending stems from a shallowly subterranean, subligneous caudex; stipules reduced to glands; leaves sessile, palmate; leaflets 3–5, 2–23 mm long, 1.5–7 mm wide, spatulate to oblanceolate or oblong, obtuse to acute; peduncles 1.4–7.5 cm long; bracts 1- to 3-foliolate; flowers 1–5, 12–16 mm long, yellow, suffused with red; calyx 4.5–8.7 mm long, the tube 3.3–4.5 mm long, shorter than the tube; pods narrowly oblong, 22–35 mm long, 2.5–3.5 mm wide, minutely strigulose to glabrate, shining, straight. Sagebrush, pinyon-juniper, mountain brush, aspen, and spruce-fir communities at 1470 to 2730 m in Beaver, Garfield, Iron, Kane, Millard, Piute, Sevier, Utah, Washington, and Wayne cos.; Nevada and Arizona; 79 (xvi).

Lotus wrightii **(A. Gray) Greene.** Wright Trefoil. [*Hosackia wrightii* A. Gray; *Anisolotus wrightii* (A. Gray) Rydb.]. Perennial, 12–60 cm tall, with erect-ascending stems from a commonly superficial caudex; stipules reduced to glands; leaves petiolate (sometimes shortly so), palmate; leaflets 3–5, 3–22 mm long, 1–5 mm wide, spatulate to oblanceolate, oblong, linear, obtuse to acute; peduncles 0–2.6 cm long; bracts 1-to 5-foliolate; flowers commonly solitary, rarely 2, 14–18 mm long, yellow, suffused with red; calyx 7.5-9.2 mm long, longer than or subequal to the tube; pods narrowly oblong, 25–34 mm long, 2–2.6 mm wide, strigulose to villosulous, straight. Ponderosa pine woods at 1830 to 2130 m in San Juan Co.; Colorado, Arizona, and New Mexico; 4 (0).

LUPINUS L.

Plants annual or perennial herbs; leaves alternate, palmately compound; stipules slender, persistent; flowers borne in terminal racemes, perfect; calyx bilabiate, the lips entire or toothed, commonly with bracteoles; petals usually blue or blue-purple, less commonly whitish, yellowish, or reddish, the banner variously reflexed, glabrous or variously hairy dorsally, the wings mostly glabrous, the keel glabrous or ciliate on upper (less commonly on lower) edges; stamens 10, monadelphous, with 5 long filaments alternating with 5 short ones; pods laterally compressed, 2- to several-seeded. *Note:* The genus is notoriously difficult because of lack of clear diagnostic features. Taxa tend to grade morphologically into each other, probably due to hybridization. Wide ranging taxa tend to intergrade with all other taxa which they contact. Because of these problems, and because of the likelihood of cleistogamy in some taxa, some specimens can be assigned to described entities only arbitrarily. The following key represents an attempt to provide meaningful determination of most of the materials from Utah. It is tentative at best.

REFERENCES

COX, B. J. 1970. A monograph of the *Lupinus ornatus* complex. M. S. Thesis, University of Missouri, 133 pp.

DUNN, D. B. 1956. Leguminosae of Nevada, Par. II. *Lupinus*. Contr. Flora Nevada 39:1–64.

———. 1957. A revision of the *Lupinus arbustus* complex of the Laxiflori. Madroño 14:54–73.

———. 1959. *Lupinus pusillus* and its relationship. Amer. Midl. Naturalist 62:500–510.

———. 1964. *Lupinus*. pp. 140–43. In: Welsh, S. L., et al. Common Utah Plants, Brigham Young University Press, Provo, Utah 312 pp.

FLEAK, L. S. AND D. B. DUNN. 1971. Nomenclature of the *Lupinus sericeus* complex (Papilionaceae). Trans. Missouri Acad. 5:85–88.

HESS, L. W. 1969. The biosystematics of the *Lupinus argenteus* complex and allies. Ph.D. Dissertation, University of Missouri. 230 pp.

1. Plants annual, the cotyledons commonly persistent .... Key I
— Plants perennial, the cotelydons not present at flowering .... Key II

KEY I. PLANTS ANNUAL

1. Leaflets long-pilose on both surfaces; cotyledons petiolate; ovules 4–6; plants of Washington Co. .... *L. concinnus*

— Leaflets variously hairy beneath, glabrous or glabrate above; cotyledons sessile; ovules 2–6; plants of various distribution 2

2(1). Flowers borne in subcapitate racemes, the rachis commonly 2 cm long or shorter 3

— Flowers borne in elongate racemes, the rachis commonly 2 cm long or longer 4

3(2). Plants subacaulescent or acaulescent, the internodes seldom to 1 cm long; upper calyx lip 2 mm long or less, entire .... *L. brevicaulis*

— Plants caulescent, with several developed internodes, at least some more than 2 cm long; upper calyx lip 3–6 mm long, bilobed .... *L. kingii*

4(2). Plants caulescent; keel petals ciliate, at least on lower margin near the base; ovules 4–6; plants of Washington Co. .... *L. sparsiflorus*

— Plants acaulescent, subacaulescent, or short caulescent; keel petals ciliate on upper edges towards the apex; ovules 2; plants of various distribution 5

5(4). Peduncles 1.5–7.5 cm long; pods not constricted between the seeds; plants subacaulescent to short caulescent, known from Washington Co. .... *L. flavoculatus*

— Peduncles 0–3.5 cm long; pods constricted between the seeds; plants mostly short caulescent, widespread in Utah .... *L. pusillus*

KEY II. PLANTS PERENNIAL

1. Leaflets glabrous above 2

— Leaflets pubescent above 6

2(1). Banner reflexed at or below the midpoint, glabrous or pubescent distally along the crest; plants of Washington Co. .... *L. laxiflorus*

— Banner reflexed above (beyond) the midpoint, hairy if at all beneath the upper calyx lip, or as if as above then not of Washington Co. 3

3(2). Leaves mainly basal, the petioles 8–13 cm long or more, coarsely hirsute; stems from a rhizome; plants of San Juan Co. .... *L. ammophilus*

— Leaves mainly well distributed along the stem, the petioles commonly less than 8 cm long, stri-gose or silvery hairy; stems from a caudex; plants of various distribution 4

4(3). Flowers 5–7 mm long; keel densely ciliate; plants of Salt Lake, Summit, and San Juan cos. .... *L. argenteus*

— Flowers 8–12 mm long; keel thinly ciliate, or the margin glabrous 5

5(4). Leaflets abruptly obtuse to rounded; racemes more than 15 cm long .... *L. argenteus*

— Leaflets obtuse to acute (rarely rounded); racemes mostly less than 15 cm long .... *L. maculatus*

6(1). Banner glabrous dorsally 7

— Banner pubescent on the back (look beneath upper lip of calyx) 11

7(6). Flowers 10–13.5 mm long; calyx saccate-gibbous or shortly spurred; leaves mainly basal; plants of Uintah and Kane cos. .... *L. wyethii*

— Flowers 7–13 mm long; calyx not especially gibbous; leaves distributed along the stem, or all leaves basal; plants of various distribution 8

8(7). Plants acaulescent or short-caulescent; leaves essentially all basal 9

— Plants caulescent; leaves distributed along the stem 10

9(8). Plants low, 3–12 cm tall; racemes sessile, surpassed by the foliage; distribution montane .... *L. caespitosus*

— Plants 15–40 cm tall; racemes shortly pedunculate, much surpassing the foliage; distributed in western Iron and Washington cos. .... *L. volutans*

10(8). Stems appressed and commonly silvery-hairy; leaflets densely silvery-hairy; plants of Iron and Washington cos. .... *L. hillii*

— Stems merely strigose, appearing green; leaflets thinly strigose; plants mainly of northern Utah .... *L. argenteus*

11(6). Calyx with a gibbous-saccate spur at base of upper lip; wings pubescent, or keel ciliate below the claws (rarely glabrous) 12

— Calyx at most gibbous at base of upper lip; wings and lower edge of keel glabrous 13

12(11). Wings not ciliate; flowers yellow or varicolored in populations; plants of far western Utah .... *L. arbustus*

— Wings or keel (or both) ciliate below the claws (rarely glabrous); flowers commonly blue-purple; plants widespread.......... *L. caudatus*

13(11). Banner reflexed at or below the midpoint, strigose to thinly strigose near the tip, or rarely hairy along the crest 14

— Banner reflexed beyond the midpoint, strigose on the back beneath the calyx lobe or over much of the back 15

14(13). Leaves mainly basal, the plants commonly less than 50 cm tall; known from Juab, Millard, Tooele, and Utah cos. .... *L. prunophilus*

— Leaves mainly well distributed along the stem, the plants commonly more than 50 cm tall; distribution broad .... *L. serviceus*

15(13). Stems velvety or woolly hairy; plants commonly of meadows and stream terraces in Duchesne, Salt Lake, Summit, Wasatch, Uintah, and Utah cos. .... *L. leucophyllus*

— Stems with appressed, ascending, spreading, or retrose hairs, but not velvety or woolly; distribu-tion and habitat various 16

16(15). Stems with spreading or retrose hairs; plants of Washington Co. 17

— Stems with suppressed or ascending hairs; plants variously distributed 18

17(16). Flowers 7–9 mm long .... *L. palmeri*

— Flowers 12–16 mm long .... *L. jonesii*

18(16). Flowers semi-orbicular viewed laterally; leaflets usually oblanceolate .... *L. alpestris*

— Flowers narrow viewed laterally; leaflets linear-oblanceolate .... *L. argenteus*

Lupinus alpestris **A. Nels.** Mountain Lupine. Perennial, 25–65 cm tall, from a woody caudex, the basal leaves commonly deciduous by anthesis; pubescence of stems mainly strigose to strigulose or pilosulous; petioles 1.5–7 cm long; leaves mainly cauline; leaflets 7–9, 8–65 mm long, 3–14 mm wide, oblanceolate to elliptic, strigulose to strigose on both sides, sometimes sparingly so above; peduncles 0.5–4 cm long; racemes 3- 59 35-flowered, 4–15 cm long in anthesis, 4–23 cm long in fruit; pedicels 2–5 mm long; flowers 8–12 mm long, blue-purple or rarely white; upper lip of calyx somewhat gibbous; banner with a central white or yellow spot, pubescent on the back near the calyx lip, reflexed above the middle; wings glabrous or rarely pubescent near the claw; keel sparingly ciliate near the apex; ovules 3–5. Sagebrush, mountain brush, pinyon-juniper, ponderosa pine, and aspen communities 1530 to 2800 m in Beaver, Box Elder, Carbon, Duchesne, Emery, Garfield, Grand, Iron, Kane, Juab, Millard, Piute, Salt Lake, San Juan, Sanpete, Sevier, Summit, Tooele, Utah, Wasatch, and Washington cos.; Saskatchewan and Montana south to Nevada, Arizona, and New Mexico. The status of mountain lupine, often cited as *L. x alpestris*, is in doubt, but is representative of the nature of taxa within the genus as a whole. Specimens occupy a morphological gradient which overlaps both *L. argenteus* sens. lat. and *L. caudatus* sens. lat. Its distribution and range of variation exceeds that of both of those taxa, however, indicating that more is involved than mere hybridization and introgression. The taxon, as described herein, serves as a kind of botanical wasteland into which those specimens are dumped which seem beyond the limits of *L. argenteus* and *L. caudatus*. The enormous range of variation is indicated in the treatment by Hess (1969), in which some 24 synonyms, mainly based on materials from Nevada, are listed for *L. alpestris*; 51 (x).

Lupinus ammophilus **Greene.** Sand Lupine. Plants perennial, 13–70 cm tall, from a rhizome-like subterranean caudex; pubescence of stems hirsute-pilose leaves mainly basal; petioles of lowermost leaves (4) 8–19 cm long, those of cauline leaves 3–14 cm long; leaflets 8–11, 12–75 mm long, 4–18 mm wide, oblanceolate to obovate, pilose beneath, glabrous above; peduncles 4–13 cm long; racemes 19- to 48-flowered, 8–25 cm long in anthesis, 8–36 cm long in fruit; flowers 8–14 mm long, blue-purple or rarely white; pedicels 4.5–9 mm long; calyx gibbous at base of upper lip; banner with a central yellow or white spot, glabrous dorsally, reflexed above the midpoint; wings glabrous, keel sparingly ciliate near the apex; ovules 3–7. Sagebrush, pinyon-juniper, mountain brush, ponderosa pine, and aspen– Douglas fir woods, commonly in sandy soils at 1830 to 2730 m in San Juan Co.; Colorado and New Mexico; 10 (iii).

Lupinus arbustus **Douglas ex Lindl.** Spurred Lupine. Perennial, 26–60 cm tall, from a woody caudex; pubescence of stems minutely strigulose; leaves scattered along the stem, but with much shorter petioles upwards; petioles 2.5–16 cm long; leaflets 7–13, 24–50 mm long, 3–10 mm wide, oblanceolate, pilose on both surfaces; peduncles 2–5 cm long; racemes 12- to 46-flowered, the axis 2.5–18 cm long in anthesis, 4–23 cm long in fruit; flowers 10–14 mm long, yellow or white or blue-purple, or all of these in populations, or in the same raceme; pedicels 1.5–6 mm long; calyx with a gibbous-saccate spur at base of upper lip, the spur 1.5–2.5 mm long; banner with a central white, yellowish, or brownish spot, pubescent dorsally, reflexed near the midpoint, wings ciliate along the upper edge near the apex; keel ciliate along the upper margin; ovules 5 or 6. Sagebrush and pinyon-juniper communities at 2135 to 2440 m in the Deep Creek Mountains, Juab and Tooele cos.; Washington east to Montana and south to California and Nevada. Our material belongs to var. ***calcaratus*** **(Kellogg) Welsh** stat. nov. based on *Lupinus calcaratus* Kellogg Proc. Calif. Acad. Sci. 2:195. 1862. [*L. laxiflorus* var. *calcaratus* (Kellogg) Dunn]. This is one of our most beautiful species of lupine; 11 (ii).

Lupinus argenteus **Pursh.** Silvery Lupine. Plants perennial, 18–90 cm tall, from a superficial caudex, puberulent to strigose on stems and petioles; leaves mainly cauline; petioles 1.5–8 cm long: leaflets 6–9, 7–95 mm long, 2–22 mm wide, oblanceolate to spatulate or almost linear, flat or folded, strigulose to strigose on both surfaces or almost to quite glabrous above; peduncles 1.5–14.5 cm long; racemes 15- to 92-flowered, 5–24 cm long in anthesis, the axis 6–29 cm long in fruit; flowers (5–7) 8.5–16 mm long, blue-purple, blue, white or rarely other hues; pedicels 1.5–6 mm long; calyx gibbous or rounded at base of upper lip; banner with a central yellow or white spot, pubsecent or glabrous dorsally, reflexed above the midpoint, the wings and keel glabrous or variously sparingly ciliate; ovules 3–6. The silvery lupine is represented in Utah by several more or less distinctive but integrading varieties. Furthermore, at least some of the phases grade further into other taxa, especially into *L. alpestris*, *L. caudatus*, and also into *L. sericeus*. Silvery lupine, along with those species, constitutes the most common and most widespread of the perennial lupines in the state. The large proportion of the specimens encountered can be segregated by use of the following, admittedly arbitrary, key.

1. Leaflets more or less evenly pubescent above, generally folded, the upper surface thus obscured 2

— Leaflets glabrous above, or with hairs scattered or merely with a few near the margin, flat or folded 3

2(1). Flowers (8) 9–11.5 mm long, narrow when viewed laterally; plants of broad distribution .... *L. argenteus* var. *tenellus*

— Flowers 11–14 mm long, orbicular when viewed laterally; plants of low elevations in east central Utah .... *L. argenteus* var. *moabensis*

3(1). Leaflets commonly folded, narrowly oblanceolate; banner usually pubescent beneath the upper lip of calyx; keel ciliate near the apex; plants of low to moderate elevations 4

— Leaflets commonly flat, oblanceolate to broadly so; banner usually glabrous dorsally, the keel margin glabrous or hairy only near the apex; plants of moderate to high elevations 5

4(3). Wings 4.5–6 mm wide; flowers 10–15 mm long, orbicular when viewed laterally; plants of central to eastern Utah .... *L. argenteus* var. *argenteus*

— Wings 3–4.5 mm wide; flowers 8–11.5 mm long, narrow when viewed laterally; plants mainly of central to western Utah .... *L. argenteus* var. *tenellus*

5(3). Keel densely ciliate near the apex; flowers 5–7 mm long; plants uncommon in Utah, passing into the following varieties .... *L. argenteus* var. *parviflorus*

— Keel moderately to sparingly ciliate near the apex; flowers commonly 8 mm long or more; plants common at high elevations 6

6(5). Flowers spreading at anthesis; stems slender, often suffused with red near the base .... *L. argenteus* var. *rubricaulis*

— Flowers pendant at anthesis; stems stout, seldom red at the base .... *L. argenteus* var. *boreus*

Var *argenteus* [L. *garrettianus* C. P. Smith, type from 1 mile west of Duchesne]. Grasslands, river terraces, sagebrush, and pinyon-juniper communities at 1575 to 3050 m in Carbon, Duchesne, Garfield, San Juan, Sevier, Uintah, and Wayne cos.; Alberta and Saskatchewan south to Oregon, California, Nevada, New Mexico, and the Dakotas. In Utah this variety passes mainly into var. *tenellus* and var. *moabensis*. From the latter it differs inter alia in pubescence position on the leaves; 27 (xi).

Var. *boreus* (C. P. Smith) Welsh comb. nov. based on *Lupinus spathulatus* var. *boreus* C. P. Smith, Species Lupinorum 746. 1952. [*L. spathulatus* Rydb., type from Wasatch Mts.; *L. alsophilus* Greene.] Spruce-fir woods, meadows, aspen, mixed conifer, and upper mountain brush communities at 2370 to 3350 m in Beaver, Carbon, Davis, Emery, Garfield, Iron, Piute, Salt Lake, Sanpete, Sevier, Summit, Utah, and Wasatch cos.; Montana and South Dakota, south to Wyoming and Colorado. The spathulate lupine forms almost a continuum with var. *rubricaulis.* They are approximately sympatric in about the same kinds of habitats through much of their ranges; 20 (viii).

Var. *moabensis* (Dunn & Harmon) Welsh stat. nov. based on *Lupinus argenteus* ssp. *moabensis* Dunn & Harmon. Mixed desert shrub and pinyon-juniper communities, often in washes, at 1400 to 1630 m in Grand and Wayne cos.; Colorado. The Moab lupine differs from var. *argenteus*, with which it is closely allied, in the features emphasized in the key. Further differential characteristics are to be found in the very early flowering time of the Moab lupine. However, this is at least partly a response to the earlier season of the lower elevation habitats, and might not be genetic; 7 (iii).

Var. *parviflorus* (Nutt.) C. L. Hitchc. [*L. parviflorus* Nutt. ex Hook. & Arn.; *L. argenteus* ssp. *parviflorus* (Nutt.) Phillips]. Spruce-fir, lodgepole pine, and aspen communities at 2270 to 2730 m in Duchesne, Salt Lake, Summit, and San Juan cos.; Idaho, Wyoming, and Colorado. Our material is mostly intermediate towards one or more of the varieties of *L. argenteus*, especially with those that occur at higher elevations; 4 (0).

Var. *rubricaulis* (Greene) Welsh comb. nov. based on *Lupinus rubricaulis* Greene, Pl. Baker. 3:35. 1901. [*L. caudatus* var. *rubricaulis* (Greene) C. P. Smith]. Spruce-fir, meadow, mixed conifer, aspen, and riparian communities at 2470 to 3370 m in Beaver, Carbon, Daggett, Duchesne, Garfield, Iron, Piute, Sanpete, Sevier, Summit, Uintah, Utah, and Wasatch cos.; Idaho, Montana, and South Dakota, south to Nevada and New Mexico. The red-stemmed lupine differs in degree only from var. *boreus*, and the two might best be treated as variants within a single variety. If they are so treated, then the name becomes var. *rubricaulis* as that name has priority in rank. Specimens from the north slope of the Uinta Mts. (Welsh 1584 BRY; Goodman 527, 169 RM) are apparently intermediate towards the more northern *L. monticola* Rydb.; 38 (xvi).

Var. *tenellus* (Douglas) Dunn. [*L. tenellus* Douglas ex G. Don; *L. laxiflorus* var. *tenellus* (Douglas) T. & G.; *L. foliosus* var. *stenophyllus* Nutt.; *L. stenophyllus* (Nutt.) Rydb.; *L. argenteus* var. *stenophyllus* (Nutt.) Davis]. Sagebrush, pinyon-juniper, mountain brush, aspen, grassland, and mixed conifer communities at 1570 to 3130 m in Cache, Carbon, Davis, Duschesne, Garfield, Grand, Juab, Millard, Piute, Salt Lake, San Juan, Sevier, Uintah, Utah, Wasatch, and Washington cos.; Alberta and Saskatchewan south to California, Arizona, New Mexico, and the Dakotas. The slender lupine is most similar to var. *argenteus*, from which it differs mainly in size of flowers that average smaller (9–11.5 mm, not 10–16). It is with this phase of *L. argenteus* that *L. alpestris* is most easily mistaken. Indeed, there is no clear way to distinguish all specimens as belonging to one or to the other; 28 (xii).

Lupinus brevicaulis S. Wats. Short-stemmed Lupine. Annual, 4–11 cm tall, from a taproot; cotyledons sessile; stems 0–2 cm long, when developed at all usually obscured by the leaf bases; leaves in a basal tuft; petioles 0.8–6.5 cm long; leaflets 3–9, 5–18 mm long, 1.5–9 mm wide, oblanceolate, flat or folded, pilose beneath, glabrous above (except marginally in some); peduncles 0.6–6.5 cm long; racemes 4- to 12-flowered, 1–2.5 cm long in anthesis, the axis 1.5–3 cm long in fruit; flowers 5.2–7 mm long, blue-purple or white; pedicels 0.3–0.8 mm long; calyx tapering to the pedicel, the upper lip very short; banner with a central yellow spot, glabrous dorsally, reflexed near the midpoint; ovules 2 or 3. Salt desert shrub, pinyon-juniper, sagebrush, blackbrush, and creosote bush communities at 830 to 1970 m in Beaver, Carbon, Daggett, Garfield, Millard, Salt Lake, Uintah, Utah, and Washington cos.; Oregon east to Colorado, and south to Arizona and New Mexico. The short-stemmed lupine forms apparent hybrids with *L. flavoculatus*; 18 (i).

Lupinus caespitosus **Nutt. ex Torr. & Gray.** Stemless Lupine. [*L. aridus* var. *utahensis* S. Wats., type from Parley's Park; *L. watsonii* Heller; *L. lepidus* var. *utahensis* (S. Wats.) C. L. Hitchc.; *L. lepidus* ssp. *caespitosus* (Nutt.) Detling]. Perennial, caespitose, 2.5–11.5 cm tall, acaulescent or essentially so, from a superficial caudex; leaves mainly basal; petioles 1–9 cm long; leaflets 5–9, 3–25 mm long, 1.5–6 mm wide, oblanceolate, mucronate, pilose on both sides; peduncles 0–2 cm long; racemes 12- to 40-flowered, 1–4 cm long in anthesis, the axis 2–6 cm long in fruit; flowers 7–8.5 mm long, blue-purple or white; pedicels 2.5–4 mm long; calyx tapering to the pedicel, the upper lip well developed; banner with a central yellow spot, glabrous dorsally, reflexed below the midpoint; ovules 2–4. Meadows, open deciduous woodland, mixed conifer, and sagebrush communities at 2130 to 3350 m in Beaver, Cache, Carbon, Emery, Grand, Kane, Garfield, Iron, Piute, Sanpete, Sevier, Summit, Uintah, Utah, Wasatch, and Wayne cos.; Oregon to Montana and south to California, Nevada, and Colorado. This distinctive taxon has been treated as belonging to an expanded *L. lepidus* Dougl. ex Lindl., but seems best recognized at specific rank, in our flora at least; 33 (xi).

Lupinus caudatus **Kellogg.** Spurred Lupine. Perennial, 21–80 cm tall, from a woody caudex; leaves mainly cauline; petioles 1–12 cm long, commonly 2–8 cm long; leaflets 5–90, 10–45 (60) mm long, 2–14 cm wide, oblanceolate to elliptic or narrowly oblanceolate, pilose on both surfaces or glabrate above; peduncles 1–6.5 cm long; racemes 10- to 57-flowered, 3–16 cm long in anthesis, the axis 4.5–17 cm long in fruit; flowers 8–12.5 (13.5) mm long, blue-purple or less commonly white; pedicels 1–3 (5) mm long; calyx with a gibbous-saccate spur 0.2–1.5 (2) mm long at the base of the upper lip; banner pubescent dorsally, reflexed at or beyond the midpoint; wings commonly ciliate above and near the claws, the keel commonly ciliate above and near the claws; ovules 3–5. Three rather weak varieties are known from Utah. They are separable only arbitrarily, but seem to represent at least trends within the variation.

1. Banner reflexed at the midpoint; leaflets rather broadly oblanceolate; plants rare in Kane Co. .... *L. caudatus* var. *cutleri*

— Banner reflexed beyond the midpoint; leaflets only rarely broadly oblanceolate; plants of various distribution 2

2(1). Leaflets bicolored, green to yellow-green above, dull green to grayish beneath; plants uncommon, of southern Utah .... *L. caudatus* var. *argophyllus*

— Leaflets more uniformly colored, either green or gray on both surfaces, or only somewhat bi-colored; plants common in much of Utah .... *L. caudatus* var. *caudatus*

Var. *argophyllus* (A. Gray) Welsh stat. nov. based on *Lupinus decumbens* var. *argophyllus* A. Gray Mem. Amer. Acad. 4:37. 1849. [*L. caudatus* ssp. *argophyllus* (A. Gray) Phillips; *L. argophyllus* (A. Gray) Cockerell; *L. laxiflorus* var. *argophyllus* (A. Gray) M. E. Jones; *L. helleri* Greene; *L. aduncus* Greene]. Pinyon-juniper, mountain brush, ponderosa pine, and grassland communities at 1570 to 2430 feet in Beaver, Garfield, Kane, and San Juan cos.; Wyoming south to New Mexico; 7 (iii).

Var. *caudatus*. [*L. holosericeus* var. *utahensis* S. Wats., type from Wasatch Mts.; *L. argentinus* Rydb.; *L. lupinus* Rydb., type from Bears Ears, Elk Mt.; *L. utahensis* Moldenke]. Sagebrush, pinyon-juniper, mountain brush, ponderosa pine, aspen, mixed conifer, and grassland communities at 1470 to 2730 m in Beaver, Box Elder, Cache, Davis, Duchesne, Garfield, Iron, Juab, Kane, Millard, Morgan, Piute, Rich, Salt Lake, San Juan, Tooele, Uintah, Utah, Wasatch, Wayne, and Weber cos.; Oregon, Idaho, and Wyoming south to California, Nevada, Arizona, and Colorado. This variety forms intermediates with *L. argenteus* (especially with var. *tenellus*), *L. hillii*, *L. sericeus*, and the other varieties of *L. caudatus*; 67 (vii).

Var. *cutleri* (Eastw.) Welsh stat. nov. based on *Lupinus cutleri* Eastw., Leafl. West. Bot. 4:192. 1945. [*L. caudatus* ssp. *cutleri* (Eastw.) Hess]. Pinyon-juniper woodland at 1570 m along the Cockscomb in Kane Co.; Arizona, Colorado, and New Mexico; 1 (i).

***Lupinus concinnus* Agardh.** Elegant Lupine. [*L. micensis* M. E. Jones; *L. orcuttii* S. Wats.; *L. concinnus* ssp. *orcuttii* (S. Wats.) Dunn.] Annual, caulescent, 6.5–20 cm tall, from a taproot; cotyledons petiolate; stems with apparent internodes; leaves mainly cauline, the lowermost the smallest; petioles 0.6–8 cm long; leaflets 5–8, 4–24 mm long, 1.5–7.5 mm wide, obovate to oblanceolate, pilose on both sides; peduncles 0.4–2 cm long; racemes 6- to 17-flowered, 2–4 cm long in anthesis, the axis 4–7 cm long in fruit; flowers 7–8.8 mm long, blue-purple (rarely white); pedicels 0.5–1.2 mm long; calyx tapering to the pedicel; upper lip well developed; banner with a central yellow spot, glabrous dorsally, reflexed at or below the midpoint; ovules 2–4. Warm desert shrublands at 770 to 1070 m in Washington Co.; New Mexico, Arizona, and Nevada. Our material belongs to var. ***orcuttii* (S. Wats.) C. P. Smith**; 10 (ii).

***Lupinus flavoculatus* Heller.** Yellow-eyed Lupine. [*L. rubens* var. *flavoculatus* (Heller) C. P. Smith; *L. odoratus* var. *flavoculatus* (Heller) Jepson]. Annual, 3–11 cm tall, from a taproot; cotyledons sessile; stems 0–2 cm long, often with at least one apparent internode; leaves mainly basal; petioles 0.5–8.5 cm long; leaflets 6–10, 5–20 mm long, 2–9 mm wide, obovate to oblanceolate, flat or folded, pilose to glabrate beneath, glabrous above, long ciliate; peduncles 1.5–7.5 cm long; racemes 9- to 16-flowered, 1.2–3 cm long in anthesis, the axis 2–4 cm long in fruit; flowers 5.1–7.2 mm long, blue-purple or less commonly white; pedicels 0.5–2 mm long; calyx tapering to the pedicel, the upper lip short; banner with a central yellow spot, glabrous dorsally, reflexed near the midpoint; ovules 2–4. Warm desert shrub and pinyon-juniper communities at 770 to 2330 m in Washington Co.; Nevada and California. This plant apparently hybridizes with *L. brevicaulis*, from which it cannot be separated in all cases. Possibly, the yellow-eyed lupine might best be treated at some infraspecific level within that taxon; 5(0).

***Lupinus hillii* Greene.** Hill Lupine. [*L. pulcher* Eastw., type from 18 miles south of Cedar City]. Perennial, 24–65 cm tall, from a woody caudex; leaves mainly cauline; petioles 0.6–8 cm long; leaflets 5–9, 7–46 mm long, 2–8 mm wide, oblanceolate to narrowly so, often folded, pilose on both surfaces though less densely so above; peduncles 0.5–18 cm long; racemes 24- to 73-flowered, 5–20 cm long in anthesis, the axis 6–23 cm long in fruit; flowers 6–8.5 mm long, blue-purple; pedicels 2–4.5 mm long; calyx gibbous at base of upper lip; banner with a central yellow spot, glabrous dorsally, reflexed near the midpoint; ovules 2 or 3. Sagebrush and pinyon-juniper to ponderosa pine communities at 2130 to 2730 m in Pine Valley Mts., Washington and Iron cos.; Arizona. The Hill lupine approaches, if not passes into, *L. palmeri* on the one hand, and into *L. caudatus* on the other. Much more material is necessary for an adequate interpretation of our somewhat meager specimens; 6 (ii).

***Lupinus jonesii* Rydb.** Jones Lupine. Perennial, 50–120 cm tall, from a woody caudex; pubescence of stems spreading-hirsute; leaves mainly cauline; petioles 1–8 cm long; leaflets 6–9, 9–60 (70) mm long, 3–13 mm wide, oblanceolate to oblong-oblanceolate, folded or flat, pilose on both surfaces; peduncles 4.5–12 cm long; racemes 18- to 65-flowered, 8–28 cm long in anthesis, the axis 9–30 cm long in fruit; flowers 12–15 (16) mm long, pallid, or blue-purple; pedicels 2–5 mm long; calyx strongly gibbous at base of upper lip; banner with a central yellow or brown spot, more or less strigose dorsally, reflexed at or beyond the midpoint; ovule number not known. Pinyon- juniper and mountain brush communities at 1170 to 2330 m in Washington Co. (type from Silver Reef); endemic. Affinities of *L. jonesii* appear to lie with *L. sericeus* through var. *barbiger*; 3(0).

Lupinus kingii **S. Wats.** King Lupine. [*L. sileri* S. Wats., type from southern Utah; *L. capitatus* Greene]. Annual, 6–24 cm tall, from a taproot; cotyledons sessile; stems with two or more apparent internodes; leaves mainly cauline; petioles 0.8–3.5 cm long; leaflet 5–7, 7–23 mm long, 2–6.5 mm wide, oblanceolate, flat or folded, long-pilose on both surfaces or glabrous medially above or overall; peduncles 0–9.5 cm long; racemes 5- to 12-flowered, 1–2.3 cm long at anthesis, the axis 1.8–3.7 cm long in fruit; flowers 7.8–9.2 mm long, blue purple or less commonly pallid; calyx somewhat gibbous at base of upper lip; banner with a central yellow spot, glabrous dorsally, reflexed below the midpoint; ovules usually 2. Two varieties are present.

1. Racemes sessile, the peduncles obsolete, contained within the foliage .... *L. kingii* var. *argillaceus*

— Racemes pedunculate, the peduncles 1–9.5 cm long, commonly produced beyond the foliate .... *L. kingii* var. *kingii*

Var. *argillaceus* (Woot. & Standl.) C. P. Smith. (*L. argillaceus* Woot. & Standl.) Pinyon-juniper woodland at 2400 m in the Henry Mts., Garfield Co.; New Mexico. This is a striking phase, which is evidently rare in Utah; 1 (0).

Var. *kingii*. Sagebrush, pinyon-juniper, mountain brush, and ponderosa pine communities at 1830 to 2440 m in Garfield, Iron, Kane, Piute, San Juan, Sevier, Wasatch (type from Heber Valley), and Washington cos.; Nevada, Arizona, New Mexico, and Colorado. 24 (iv).

Lupinus latifolius **Agardh.** Broad-leaved Lupine. Perennial, 30–120 cm tall, from a branching caudex; pubescence appressed strigose or almost lacking; leaves mainly cauline; petioles 4–20 cm long, leaflets 5–11, 25–90 mm long, 4–20 mm wide, oblong to elliptic or oblanceolate, flat, glabrous above, thinly appressed-strigose beneath; racemes 10- to 35-flowered, 8–25 cm long in anthesis, 10–40 cm long in fruit; flowers 10–14 cm long, blue to pinkish, fading brown; pedicels 6–12 mm only; calyx not gibbous at the base; banner with a central yellow spot; glabrous dorsally, reflexed below the midpoint; ovules 7–10. Oakbrush and streamside communities at ca. 1230 m in Washington (Zion National Park) Co.; California, Oregon, Washington. Our materials appear to belong to **var. *columbianus* (Heller) C. P. Smith.** [*L. columbianus* Heller] 2(0).

Lupinus leucophyllus **Dougl. ex Lindl.** White-leaved Lupine. [*L. eatonanus* C. P. Smith, type from Hailstone]. Perennial, 40–90 cm tall or more, from a woody caudex; pubescence of stems dense, appressed to spreading; leaves mainly cauline; petioles 1.2–16 cm long; leaflets 7–10, 9–70 mm long, 3–13 mm wide, oblanceolate, flat or folded, villous-pilose on both surfaces; peduncles 2.5–5.5 cm long; racemes 22- to 70-flowered, 7–18 cm long in anthesis, the axis 8–19 cm long in fruit; pedicels 2.5–5 mm long; flowers 10–15 mm long, blue-purple or less commonly pallid; calyx gibbous to saccate-gibbous at base of upper lip; banner with a central yellow spot, densely hairy dorsally, reflexed above the midpoint; ovules 4–6. Terraces at 1450 to 2300 m in Duchesne, Summit, Uintah, Utah, and Wasatch cos.; Washington south to Nevada and east to Wyoming. The white-leaved lupine forms apparent hybrids with *L. caudatus*, among others; 9 (iv).

Lupinus maculatus **Rydb.** Spotted Lupine. Perennial, 40–85 cm tall, from a woody caudex; pubescence of stems appressed or subappressed or lacking; leaves mainly cauline; petioles 1.8–4 cm long; leaflets 5–8, 14–75 mm long, 2.5–18 mm wide, oblanceolate, mainly flat, sparingly pilose beneath, glabrous above, ciliate, obtuse to acute apically; peduncles 0.8–9 cm long; racemes 20- to 39 (50) -flowered, 5–15 (23) cm long in anthesis, the axis 8–25 cm long in fruit; pedicels 2–5 mm long; flowers 8.5–14 mm long, blue-purple or white, fading tan; calyx more or less gibbous at base of upper lip; banner with a central brown (or fading brown) spot, glabrous dorsally, reflexed above the midpoint; ovules 4 or 5. Aspen-conifer, meadow, and open conifer communities at 2230 to 2730 m in Davis, Salt Lake (?), Sevier, Utah [type from P. V. (Pleasant Valley) Junction], and Weber cos.; Idaho. Spotted lupine is a near ally of *L. argenteus* var. *boreus* and var. *rubricaulis*, with which it forms apparent hybrids. Perhaps it would best be treated at infraspecific rank in that species; 10 (i).

Lupinus palmeri S. Wats. Palmer Lupine. Perennial, 24–60 cm tall, from a woody caudex; pubescence of stems more or less spreading-ascending (at least some); leaves mainly cauline; petioles 0.8–10 cm long; leaflets 6–10, 10–48 mm long, 3–8 (10) mm wide, oblanceolate, flat or folded, pilose on both surfaces; peduncles 0.5–5.5 (7) cm long; racemes 14- to 55-flowered, 4–15 cm long in anthesis, the axis 12–20 cm long in fruit; flowers 1.5–11 mm long, blue-purple; pedicels 1.2–4 mm long; calyx more or less gibbous at base of upper lip; banner with a central yellow spot, usually pubescent dorsally, reflexed at or beyond the midpoint; ovules 2–6. Pinyon-juniper and sagebrush communities at 1830 to 2130 m in Washington Co.; Nevada, Arizona, and New Mexico. The Palmer lupine, as it is known in Utah, is closely related to *L. hillii*, from which it is distinguished with some difficulty. Additional materials might dictate a change in status for this poorly known entity; 5(0).

Lupinus prunophilus **M. E. Jones.** Robinson Lupine. [*L. wyethii* var. *prunophilus* (M. E. Jones) C. P. Smith; *L. arcticus* var. *prunophilus* (M. E. Jones) C. P. Smith; *L. polyphyllus* ssp. *polyphyllus* var. *prunophilus* (M. E. Jones) Phillips; *L. tooelensis* C. P. Smith, type from Johnson Canyon, Deep Creek Mts.] Perennial, 23–65 cm tall, from a woody caudex; pubescence of stems spreading-hirsute; leaves mainly basal; petioles of lowermost leaves 7–30 cm long; leaflets 8–13, 15–75 above; peduncles 4–10 cm long; racemes 25- to 68-flowered, 6–23 cm long, the axis 8–35 cm long in fruit; flowers 10–16 mm long, blue-purple; pedicels 3.5–8 mm long; calyx gibbous at base of upper lip; banner with a yellow spot, glabrous dorsally, reflexed near the midpont; wings glabrous; keel sparingly ciliate near the apex; ovules 3–6. Sagebrush, pinyon-juniper, and mountain brush communities at 1530 to 2130 m in Juab (type from Robinson), Millard, Tooele, and Utah cos.; Washington south to Nevada and east to Montana, Wyoming, and Colorado. The Robinson lupine has been regarded by Hess (1969) as *L.* x *prunophilus*, but that designation seems inconsistent with the material at hand. The populations in Utah are better defined than some of the other taxa treated as species; 13 (ii).

Lupinus pusillus Pursh. Dwarf Lupine. Annual, 3–24 cm tall, from a taproot; cotyledons sessile; pubescence of stems and petioles spreading long-hairy; leaves mainly cauline; petioles 1–9 cm long; leaflets 3–9 (14), 11–48 mm long, 2–10 mm wide, oblanceolate, flat or folded, long-pilose beneath, glabrous above; peduncles 0.5–3.5 cm long; racemes 4- to 38-flowered, 1–17 cm long in anthesis, the axis 4–21 cm long in fruit; flowers 8.5–12 mm long, blue or variously pink or white; pedicels 1–3.5 mm long; calyx tapering to the pedicel; banner with a central yellow spot, glabrous dorsally, reflexed near the midpoint; ovules 2; pods constricted between the seeds. Three poorly differentiated and intergrading varieties are present in Utah. The following arbitrary key will serve to segregate most materials.

1. Peduncles seldom more than 1 cm long; inflorescence shorter than the leaves; banner 5 mm wide or less .... *L. pusillus* var. *intermontanus*

— Peduncles commonly 1–3.5 cm long; inflorescence usually longer than the leaves; banner 6–10 mm wide 2

2(1). Calyx tube and pedicel glabrous; corolla commonly blue; plants completely transitional with the next .... *L. pusillus* var. *rubens*

— Calyx tube and pedicel pilose; corolla blue or pale to white .... *L. pusillus* var. *pusillus*

Var. *intermontanus* (Heller) C. P. Smith. [*L. intermontanus* Heller; *L. pusillus* ssp. *intermontanus* (Heller) Dunn]. Dunes and other sandy sites in mixed desert shrub, pinyon-juniper, and mountain brush communities at 1130 to 1770 m in Duchesne, Emery, Garfield, Kane, Millard, Salt Lake, San Juan, Tooele, and Wayne cos.; Arizona, California, Idaho, Montana, Nevada, Oregon, Washington, and Wyoming. The long-hairy raceme axis and pedicels, along with the narrow banner and the short racemes, are diagnostic; 23 (iv).

Var. *pusillus*. Salt desert shrub, mixed desert shrub, and pinyon-juniper communities, commonly in sand, at 1230 to 1970 m in Emery, Garfield, Grand, Kane, San Juan, Uintah, and Wayne cos.; Alberta and Saskatchewan south to Arizona, New Mexico, and Kansas; 39 (ix).

Var. *rubens* (Rydb.) Welsh stat. nov. based on *Lupinus rubens* Rydb., Bull. Torrey Bot. Club 34:45. 1907. [*L. odoratus* var. *rubens* (Rydb.) Jepson; *L. pusillus* ssp. *rubens* (Rydb.) Dunn]. Mixed desert shrub and blackbrush communities, commonly in sand, at 800 to 1650 m in Garfield, San Juan, Washington (type from St. George), and Wayne cos.; Nevada, Arizona, and Colorado; 7 (ii). The maintenance of var. *rubens* in any taxonomic rank is dubious, since the main diagnostic features, i.e., the glabrous pedicel and calyx tube, do not fall into an either/or situation. Never-the-less, the phase of low elevations, mainly in Washington Co., do represent a trend, which, although based on this tenuous pubescence feature alone, seems worthy of taxonomic recognition.

Lupinus sericeus Pursh. Silky Lupine. Perennial, 30–120 cm tall, from a branching caudex; pubescence of stems short-villous to pilose or strigose, sometimes spreading; petioles 1.2–9 cm long; leaflets 5–9, 7–78 mm long, 2–15 mm wide, oblanceolate, commonly flat (at least some), pilose to puberulent on both surfaces or glabrous to glabrate above; peduncles 1.3–9 cm long; racemes 14- to 70-flowered, 6–28 cm long in anthesis, the axis 8–37 cm long in fruit; flowers 10–16 mm long, blue, blue-purple, pale, or white; pedicels 2–7 mm long; calyx more or less gibbous at the base of upper lip; banner with yellow or brown eyespot, strigose along the dorsal crest or more widely; ovules 5–7. Widely distributed in Utah, and constituting one of the three important species complexes in the state, *L. sericeus*, along with *L. argenteus* and *L. caudatus*, occupy most of the range available to perennial lupines. Three main population types are segregated in the following key.

1. Flowers white in populations, the eyespot and veins commonly dark brown or fading dark brown; plants mostly from Sevier Co. southward .... *L. sericeus* var. *barbiger*

— Flowers commonly blue or blue-purple in populations, intergrading with the preceding when in contact, the eyespot yellow or brown 2

2(1). Leaflets sparingly pubescent to glabrous above; plants mostly of central southern Utah; intergrading with the following .... *L. sericeus* var. *marianus*

— Leaflets uniformly puberulent to pilose above; plants of broader distribution .... *L. sericeus* var. *sericeus*

Var. *barbiger* (S. Wats.) Welsh comb. nov. based on *Lupinus barbiger* S. Wats., Proc. Amer. Acad. 8:528. 1873. [*L. leucanthus* Rydb., type from Springdale]. Sagebrush and mountain brush communities at 1930 to 2730 m in Garfield, Kane (type from Kane Co.), Piute, Sevier, Washington, and Wayne cos.; endemic. This is the common white-flowered variety of south-central Utah; it forms intermediates at points of contact with both var. *sericeus* and var. *marianus*; 29 (xiii).

Var. *marianus* (Rydb.) Welsh stat. nov. based on *Lupinus marianus* Rydb. Bull. Torrey Bot. Club 34:41. 1907. [*L. sericeus* ssp. *marianus* (Rydb.) Fleak & Dunn]. Sagebrush, pinyon-juniper, mountain brush, ponderosa pine, aspen, and spruce-fir communities at 1770 to 2870 m in Garfield, Piute (type from Bullion Creek), and Sevier cos.; endemic; 8 (iv).

Var. *sericeus*. [*L. aegra-ovium* C. P. Smith, type from Salina Canyon; *L. huffmanii* C. P. Smith, type from Salina Canyon; *L. sericeus* ssp. *huffmanii* (C. P. Smith) Fleak & Dunn; *L. larsonanus* C. P. Smith, type from Salina Canyon; *L. puroviridis* C. P. Smith, type from Salina Canyon; *L. quercus-jugi* C. P. Smith, type from Salina Canyon vicinity; *L. rickeri* C. P. Smith, type from Salina Canyon; *L. salinensis* C. P. Smith, type from Salina Canyon; *L. egglestonianus* C. P. Smith; *L. flexuosus* Lindl.; *L. sericeus* var. *flexuosus* (Lindl.) C. P. Smith]. Sagebrush, mountain brush, pinyon-juniper, ponderosa pine, aspen, spruce-fir and meadow communities at 1770 to 3130 m in Beaver, Carbon, Emery, Garfield, Grand, Juab, Kane, Piute, Salt Lake, Sevier, Summit, Tooele, Utah, Wasatch, Wayne, and Weber cos.; British Columbia east to Alberta and south to California, Arizona, and New Mexico; 60 (xxv).

***Lupinus sparsiflorus* Benth.** Mohave Lupine. Annual, 9–38 cm tall, from a taproot; cotyledons sessile; pubescence of stems appressed or ascending, of two lengths; leaves mainly cauline; petioles 1.4–8 cm long; leaflets 5–9, 5–35 mm long, 1–4 mm wide, elliptic-oblong to oblanceolate, flat or folded, long-pilose on both surfaces, less densely hairy above; peduncles 1.3–5 cm long; racemes 8- to 46-flowered, 4–23 cm long in anthesis, the axis 6–29 cm long in fruit; flowers 8.5–11 mm long, blue-purple or rarely white; pedicels 2–5 mm long; calyx gibbous at base or upper lip; banner with a central yellow spot, glabrous dorsally, reflexed beyond the midpoint; ovules 4–6. Joshua tree, cresote bush, and mixed warm desert shrub communities at 670 to 1100 m in Washington Co.; Arizona, Nevada, California, and Mexico. Our material belongs to **var. *mohavensis* (Dziekanowski & Dunn) Welsh** stat. nov. based on *Lupinus sparsiflorus* ssp. *mohavensis* Dziekanowski & Dunn Aliso 6:48. 1966; 10 (ii).

***Lupinus volutans* Greene.** Rolled Lupine. Perennial, 15–40 cm tall, caespitose from a branching caudex, short-caulescent; pubescence of stems long pilose; leaves mainly basal; petioles 4–19 cm long; leaflets 5–7, 6–40 mm long, 2–9 mm wide, oblanceolate to elliptic, flat or folded, long pilose on both surfaces, less densely so above; peduncles 0.8–3 cm long; racemes 28- to 85-flowered, 6–23 cm long in anthesis, the axis 10–30 cm long in fruit; flowers 12–14 mm long, blue-purple; pedicels 1–3 mm long; calyx only somewhat gibbous at base of upper lip; banner with a central yellow spot, glabrous dorsally, reflexed at or below the midpoint; ovules 3 or 4. Sagebrush and pinyon-juniper communities at 1670 to 1850 m in southwestern Iron and northwestern Washington cos.; Nevada. The rolled lupine is allied to the *Lupinus lepidus* complex, and has been included by some authors as a synonym of phases of that group. In Utah it is a distinctive plant, with its nearest ally being *L. caespitosus*, from which it differs both morphologically and ecologically; 2 (i).

***Lupinus wyethii* S. Wats.** Wyeth Lupine. Perennial, 19–45 cm tall, from a branching superficial or scarcely subterranean caudex; pubescence of stem appressed-ascending, of two lengths; leaves basal and cauline; petioles of lowermost leaves 3.5–13 cm long; leaflets 6–9, 8½3 mm long, 1.2–7 mm wide, narrowly oblanceolate, commonly folded, pilose on both surfaces; peduncles 3.5–11 cm long; racemes 13- to 49-flowered, 9–30 cm long in anthesis, the axis 10–35 cm long in fruit; flowers 10–13.5 mm long, blue-purple; pedicels 3–8 mm long; calyx gibbous to saccate-spurred at base of upper lip; banner with a yellow eyespot, glabrous dorsally, reflexed near the midpoint; wings glabrous dorsally, reflexed near the midpoint; wings glabrous; keel ciliate along the upper margin near the apex; ovules 5 or 6. Wash bottoms and terraces or rimrock in pinyon-juniper and riparian communities at 1470 to 1900 m in Duchesne, Kane, and Uintah cos.; British Columbia east to Saskatchewan and south to Washington, Idaho, and Wyoming. Our material differs from the main body of specimens considered as belonging within var. *wyethii*, whose range is mostly north of the Utah outliers. Specimens from Kane Co. differ from the northern materials in having fewer leaflets (6–9, not 8–13), in possessing petioles which average shorter, and in more attenuate racemes. There are additional more subtle differences. Possibly this population is worthy of taxonomic recognition; 12 (iv).

MEDICAGO L.

Plants annual or perennial herbs, caulescent, from a taproot or a caudex; leaves alternate, pinnately trifoliolate, the leaflets serrate in the distal half or less; stipules herbaceous, often toothed; flowers papilionaceous, borne in axillary, pedunculate racemes or heads; bracts subulate; calyx 5-toothed; petals 5, yellow, white, blue, pink, lavender, or purple; stamens 10, diadelphous; ovary enfolded by the staminal sheath, the style subulate, irritable; pods curved to spirally coiled, 1- to several-seeded, indehiscent, reticulate or spiny.

1. Flowers 2–3 mm long; inflorescence less than 10 mm long in anthesis; pods coiled through a single spiral, 1-seeded, unarmed; plants annual, prostrate to decumbent or rarely erect .... *M. lupulina*

— Flowers 4–10 mm long; inflorescence longer than 10 mm long (including flower length), or pods differing from above; plants various 2

2(1). Flowers 4–5 mm long, yellow, 2–5 per raceme; racemes less than 10 mm long; pods armed with prickles, several-seeded; plants annual .... *M. polymorpha*

— Flowers 6–10 mm long, yellow or blue, lavender, pink, purple, or white, 6 to many on at least some racemes; racemes longer than 10 mm; pods unarmed, several-seeded; plants usually perennial 3

3(2). Flowers yellow (sometimes tinged violet); pods merely curved; plants uncommon .... *M. falcata*

— Flowers blue, pink, lavender, purple, or white; pods spirally coiled; plants abundant to common .... *M. sativa*

Medicago falcata L. Yellow Alfalfa. Perennial (rarely functionally annual), 40–100 cm tall or more, the stems erect or ascending, strigulose; stipules 4–12 mm long, persistent, conspicuously veined; leaves short-petiolate, the leaflets linear, oblong, oblanceolate, or elliptic, 6–20 mm long, 1–6 (10) mm wide, few-toothed, tridentate or merely apiculate apically, strigulose beneath; peduncles subequal to the subtending leaves or longer; racemes 6- to 20-flowered, mostly 10–20 mm long; flowers 6–9 mm long, yellow, sometimes suffused with violet; calyx campanulate, the tube 1–2 mm long, the teeth 1.5–3 mm long, lance-subulate; pods 6–10 mm long, merely curved, unarmed, several-seeded. Sparingly cultivated forage plant, escaping and persisting; introduced from the Old World. The yellow alfalfa forms hybrids with *M. sativa*, and is sometimes considered as a phase of that species; 2 (i).

Medicago lupulina L. Black Medick, Hop Clover. Annual, the stems prostrate to decumbent or sometimes erect, 10–40 cm long; stipules entire or nearly so, 3–6 mm long, persistent; leaves short-petiolate, the leaflets cuneate to obcordate, 4–15 mm long, 2–12 mm wide, toothed in the apical one-third (rarely more), pubescent to glabrous; peduncles mostly equaling or surpassing the subtending leaves; racemes 6-to 25-flowered, less than 10 mm long at anthesis (to 25 mm long in fruit); flowers 2–3 mm long, yellow; calyx campanulate, about 1 mm long; pods spiral through about 1 coil, unarmed, 1-seeded. Introduced weedy species of lawns, fields, and other sites in much of Utah (Cache, Garfield, Juab, Kane, Piute, Rich, Salt Lake, San Juan, Summit, Utah, Wasatch, Washington, and Weber cos.), where it should be considered as cosmopolitan; introduced from Europe; 35 (v).

Medicago polymorpha **L.** Bur Clover. (*M. hispida* Gaertn.). Annual, the stems prostrate to erect, 10–40 cm long; stipules deeply divided into long teeth, mostly 3–7 mm long; leaves short-petiolate, the leaflets cuneate to obovate or obcordate, 10–25 mm long, 6–18 mm wide, toothed in the apical one-third or more, pubescent to glabrous; peduncles mostly shorter than the subtending leaves; racemes 2- to 5-flowered, less than 10 mm long; flowers 4–5 mm long, yellow; calyx campanulate, the tube 1–1.5 mm long, the lance-subulate teeth 1–2 mm long; pods spirally coiled, armed with spines, several-seeded. Rare weedy species of cultivated land in Utah, but to be expected almost anywhere; introduced from Europe; 1(0).

Medicago sativa **L.** Alfalfa, Lucern. Perennial, or functionally annual, the stems 40–100 cm long or more, ascending to erect, finally sprawling, strigulose, stipules entire or toothed, 4–12 mm long, persistent; leaves short-petiolate, the leaflets elliptic to oblanceolate, 8–40 mm long, 2–15 mm wide, apically few-toothed, pubescent; peduncles often surpassing the subtending leaves; racemes 6- to 25-flowered, 10–35 mm long or more; flowers 6–10 mm long, blue, lavender, pink, purple, or white; calyx campanulate to short-cylindric, the tube 1.5–2.5 mm long, the lance-subulate teeth 2–4 mm long; pods spirally coiled, unarmed, several-seeded. Introduced forage plant, escaping and persisting, now almost or quite cosmopolitan at moderate and lower elevations (Cache, Carbon, Garfield, Kane, Salt Lake, San Juan, Sanpete, Sevier, Tooele, Utah, Washington, and Weber cos.); introduced from Europe. This is one of the most important forage plants grown in the state; 35 (iv).

MELILOTUS L.

Plants annual or biennial herbs, caulescent, from a stout taproot; leaves alternate, pinnately trifoliolate, the leaflets dentate-serrate in the distal half or more; stipules herbaceous, distinct, subulate, entire or hastately lobed; flowers papilionaceous, borne in axillary, pedunculate racemes; bracts subulate; calyx 5-toothed; petals 5, white or yellow, the keel obtuse; stamens 10, diadelphous; ovary enfolded by the staminal sheath, the style subulate, not irritable; pods straight, ovoid, reticulately veined or cross-ribbed, unarmed, glabrous, 1- to 2-seeded, indehiscent.

1. Flowers 2–3 mm long, yellow; pedicels less than 1 mm long; plants known from Washington Co. .... *M. indicus*

— Flowers 3–7 mm long, white or yellow; pedicels 1–2 mm long; plants widespread 2

2(1). Flowers white; pods reticulately veined .... *M. albus*

— Flowers yellow; pods cross-ribbed .... *M. officinalis*

Melilotus albus **Descr. ex Lam.** White Sweet Clover. Annual or biennial, the stems commonly 50–150 cm tall or more, erect, strigulose; stipules entire or hastately lobed, mostly 5–10 mm long, persistent; leave short-petiolate, the leaflets obovate to elliptic or oblanceolate, 8–35 mm long, 1–15 mm wide, pubescent or glabrous; peduncles commonly surpassing the subtending leaves; racemes 38- to 115-flowered, 28–125 cm long or more; flowers 4–5.5 mm long, white; calyx campanulate, the tube 1.2–1.8 mm long, the teeth 1–1.5 mm long, acuminate; pods 2.5–6 mm long, reticulately veined, 1- to 2-seeded. Introduced forage plant, now widely established in Beaver, Box Elder, Cache, Garfield, Grand, Juab, Kane, Salt Lake, San Juan, Sanpete, Sevier, Tooele, Utah, Washington, and Wayne cos., and likely cosmopolitan; introduced from Europe. This plant is an excellent source of honey for domestic bees. Plants of sweet clover contain coumarin, and are responsible for production of bloat in livestock; 49 (xii).

Melilotus indicus **(L.) All.** India Sweet Clover. Annual or winter annual, the stems 20–80 cm tall, erect, glabrous or strigose; stipules lance-subulate, 4–6 mm long, persistant; leaves short-petiolate, the leaflets obovate to oblanceolate or elliptic, 7–30 mm long, 3–14 mm wide, glabrous; peduncles shorter to longer than the subtending leaves; racemes 21- to 43-flowered, 8–30 mm long; flowers 2–3 mm long, yellow (fading white); calyx campanulate, the tube 0.6–0.8 mm long, the teeth 0.5–0.7 mm long, triangular; pods 1.5–2 mm long, reticulately veined, 1-seeded. Adventive weedy plants of lower elevations in Washington Co.; introduced from Eurasia; 3 (0).

Melilotus officinalis **(L.) Lam.** Yellow Sweet Clover. (*Trifolium melilotus officinalis* L.). Annual, winter annual, or biennial, the stems 50–150 cm tall or more, erect, strigulose; stipules entire or with 1–3 basal teeth, 3–10 mm long, persistent; leaves shortly petiolate, the leaflets cuneate to elliptic or oblanceolate, 8–38 mm long, 3–16 mm wide, pubescent or glabrous; peduncles shorter to longer than the subtending leaves; racemes 20- to 65-flowered, 1.8–11 (14) cm long; flowers 4.5–6 (7) mm long, yellow, fading cream; calyx campanulate, the tube 1–1.8 mm long, the teeth 1–1.5 mm long, acuminate; pods 3–5 mm long, cross-ribbed, 1- to 2-seeded. Common ruderal weed of almost cosmopolitan distribution in Box Elder, Cache, Carbon, Daggett, Garfield, Grand, Kane, Millard, Piute, Salt Lake, San Juan, Sanpete, Sevier, Tooele, Utah, Wasatch, Washington, Wayne, and Weber cos., and likely anywhere; introduced from Europe. This plant has about the same attributes and shortcomings as does *M. albus*, with which it often occurs; 58 (xi).

ONOBRYCHIS Adans.

Perennial herbs, caulescent, from a caudex and taproot; leaves alternate, odd-pinnate; stipules adnate to the petiole base, the lowermost amplexicaul but not connate; flowers papilionaceous, in axillary racemes, each subtended by a bract; bracteoles 2; calyx 5-toothed; petals 5, red-purple to lavender or pink, the keel much longer than the wings, abruptly bow-shaped; stamens 10, essentially diadelphous; ovary enclosed in the staminal sheath, the style glabrous; loment reduced to 1 segment, this armed with prickles.

Onobrychis viciifolia **Scop.** Sainfoin, Holy Clover. [*Hedysarum onobrychis* L.; *O. onobrychis* (L.) Rydb.; *O. sativa* Lam.] Perennial, caulescent, 20–45 cm tall, from a branching, superficial caudex; stems ascending to erect; stipules 3–12 mm long, all more or less amplexicaul; leaves 3–12 mm long; leaflets 11–21 (27), 8–25 mm long, 2–7 mm wide, oblong to elliptic or oblanceolate, pilose mainly along veins beneath, glabrous above; peduncles 8–19 cm long; racemes 14- to 39 (50) -flowered, the flowers ascending-spreading at anthesis, the axis 4–15 cm long in fruit; bracts 2.5–4.5 mm long; pedicels 0.2–1.5 mm long; bracteoles 1; calyx 5.5–6.5 mm long, the tube 2.3–3 mm long, campanulate, the teeth 2.2–4 mm long, subulate; flowers 10–13 mm long, red-purple, lavender, or pink; loment sessile, ascending, armed with prickles. Introduced forage plant, escaping and persisting in Juab, Salt Lake, Sanpete, and Utah cos., and likely elsewhere; native to Europe. The genus is closely allied to *Hedysarum* (q.v.); 4 (i).

OXYTROPIS DC.

Perennial, caulescent, or acaulescent herbs, from a taproot and caudex; leaves alternate or basal, odd-pinnate; stipules adnate to the petiole base, often connate-sheathing, flowers papilionaceous, scapose or borne in axillary racemes, each subtended by a single bract; bracteoles 0 (rarely 2); calyx 5-toothed; petals 5, pink, pink-purple, or white, the keel shorter than the wings, the keel-tip produced into a porrect beak; stamens 10, diadelphous; ovary enfolded in the staminal sheath, the style glabrous; pods sessile or stipitate, straight, erect, ascending, or spreading-declined, 1-loculed, 2-loculed, or partially 2-loculed by intrusion of the ventral (upper) suture, dehiscent apically or throughout.

REFERENCES

BARNEBY, R. C. 1952. A revision of the North American species of *Oxytropis* DC. Proc. Calif. Acad. Sci. IV. 27:177–312.

1. Plants shortly caulescent; stipules only somewhat adnate to the petioles; flowers 5–9 mm long; pods spreading-declined .... *O. deflexa*

— Plants acaulescent, scapose; stipules adnate to petioles through half their length or more; flowers commonly more than 9 mm long; pods erect or ascending 2

2(1). Bracts, calyx teeth, pods, and sometimes other plant parts glandular-viscid .... *O. viscida*

— Bracts, calyx teeth, pods, and other plant parts pilose to villosulous, but not at all glandular-viscid 3

3(2). Racemes 1- to 5-flowered, subcapitate 4

— Racemes 6- to many-flowered, the axis elongate, only rarely subcapitate 7

4(3). Calyx swollen at full anthesis, becoming inflated and finally enclosing the pod; pods rarely longer than 10 mm; plants of Daggett Co. .... *O. multiceps*

— Calyx campanulate, not turgid, not becoming inflated or enclosing the fruit, at length rupturing along one side; pods often over 10 mm long 5

5(4). Pods oblong-ellipsoid, not inflated, leathery in texture; flowers 1–4; plants of mountain summits in north central to southern Utah .... *O. parryi*

— Pods ovoid, inflated, papery in texture; flower number various; plants of various distribution 6

6(5). Flowers 6–12 mm long; leaflets 7–17; plants of limestone, gravel, and basalt in southern Utah .... *O. oreophila*

— Flowers (11) 14–17 mm long; leaflets 3–7; plants of shale and limestone in Uintah, Emery, and Garfield cos. .... *O. jonesii*

7(6) Plants dwarf, seldom over 10 cm tall; flowers 6–12 mm long; growing on limestone, gravel, and basalt in southern Utah .... *O. oreophila*

— Plants mainly over 10 cm tall; flowers 14–27 mm long; growing on various substrates and with distribution various but seldom as above 8

8(7). Petals bright pink-purple 9

— Petals white or ochroleucous to yellowish 10

9(8). Pubescence of basifixed hairs; calyx somewhat swollen and accrescent; plants of Daggett Co. .... *O. besseyi*

— Pubescence of malphighian hairs; calyx not swollen or enlarging; plants of wide distribution .... *O. lambertii*

10(8). Wing petals dilated apically, at least 5 mm wide; plants of broad distribution .... *O. sericea*

— Wing petals not especially dilated, less than 5 mm wide, plants known from the north slope of the Uinta Mts. .... *O. campestris*

Oxytropis besseyi **(Rydb.) Blankinship.** Bessey locoweed. [*Aragallus besseyi* Rydb.] Caespitose, acaulescent, 8–28 cm tall; pubescence basifixed, silky-pilose to subtomentose; stipules pilose-tomentose; leaves 6–20 cm long; leaflets 11–13 (25), 6–25 mm long, 2–6 mm wide, lanceolate to lance-oblong or elliptic, silky-pilose; scapes 6–19 cm long, subtomentose; racemes 8- to 22-flowered, the flowers spreading-ascending at maturity, the axis 2.5–8 cm long in fruit; bracts silky-pilose; flowers 18–25 mm long, brilliant pink-purple; calyx 10–13 mm long, the tube swollen at anthesis, 7.5–9.5 mm long, the teeth 2.5–4 mm long, lance subulate; pods sessile or nearly so, strongly inflated, the body ovoid, 5–8 mm thick, semibilocular, densely villous. Pinyon-juniper community at 1830 to 2130 m in Daggett Co.; Montana, Idaho, Wyoming, and Colorado. Our material is assignable to var. ***obnapiformis*** **(C. L. Porter) Welsh** comb. nov. based on *Oxytropis obnapiformis* C. L. Porter, Madroño 9:133. 1947. Maintenance of *O. obnapiformis* at specific rank was discussed by Barneby (1952), who noted that the features used as diagnostic ones "are not strong characters." That information along with the apparent intermediacy of Utah specimens with those of var. *fallax* Barneby, from nearby in Wyoming, dictates that the reduction of *O. obnapiformis* is necessary. In specimens from Utah, the leaflet number is fewer than in more typical plants from northwestern Colorado, but the pubescence and pod features seem to substantiate the recognition of the taxon at varietal rank; 5 (0).

Oxytropis campestris **(L.) DC.** Yellow Locoweed. [*Astragalus campestris* L.]. Caespitose, acaulescent, 4–18 cm tall; pubescence basifixed, mainly pilose; stipules glabrous or sparingly pilose; leaves 1.5–12 cm long; leaflets 7–17, 3–23 mm long, 1–6 mm wide, oblong to lanceolate or obovate; scapes 2.5–15 cm long, pilose to glabrate; flowers 14–20 mm long, ochroleucous; calyx 7–10 mm long, the tube cylindric, the teeth 1.5–3 mm long, triangular-subulate, pods 8–18 mm long, erect, sessile or subsessile, pilose, partially bilocular by intrusion of the ventral suture. Meadows and open woods at 2270 to 2600 m in Summit Co. (Goodmans Ranch, Bear River, E. & L. Payson 4868 POM); Oregon, Washington, Idaho, Montana, and Colorado. The range as given is for our materials only, which belong to var. ***cusickii*** **(Greenm.)** Barneby (*O. cusickii* Greenm.). The species proper is circumboreal; 1 (0).

Oxytropis deflexa **(Pallas) DC.** Stemmed Oxytrope. Shortly caulescent to subacaulescent, (5) 7–48 cm tall; pubescence basifixed, villous-pilose; leaves 2–20 cm long; leaflets 23–41, 3–24 mm long, 1–7 mm wide, lance-oblong to lanceolate, pilose on both surfaces, quite sessile; peduncles 3.5–32 cm long, villous-pilose; racemes 3-to 25-flowered, the flowers ascending to declined at anthesis, the axis 3.5–10 cm long in fruit; bracts pilose; flowers 5–10.5 mm long, whitish, lilac, or blue-purple; calyx 4–8 mm long, the tube 2–3.5 (4.2) mm long, campanulate, the teeth 1.5–5 mm long, lance-subulate; pods spreading-declined, subsessile to shortly stipitate, the body oblong to ellipsoid, 8–18 mm long, 3–4.5 mm wide, subunilocular, pilosulous. Two rather distinctive varieties occur in Utah.

1. Plants subacaulescent; flowers 9–10.5 mm long, blue-purple; racemes 15–22 mm broad at anthesis; of high elevations in Uinta Mts. .... *O. deflexa* var. *deflexa*

— Plants commonly short caulescent; flowers 5–9 mm long, whitish, lilac, or blue-purple; racemes commonly less than 17 mm wide at anthesis; of moderate elevations, widespread .... *O. deflexa* var. *sericea*

Var. *deflexa*. [*Astragalus deflexus* Pallas]. Meadows at 2750 to 3350 m in Duchesne and Summit (Goodrich 824, BRY) cos; Colorado and north to Yukon; Asia. The North American material here assigned to var. *deflexa* might well represent a distinct taxon, worthy of recognition at varietal level; 2 (0).

Var. *sericea* Torr. & Gray. Moist meadows, streambanks, and gravel bars in aspen, mixed conifer, and sagebrush communities at 2430 to 3050 m in Emery, Garfield, Grand, Iron, Summit, Uintah (?), and Wayne cos; Alaska and Yukon south to California, New Mexico, and North Dakota; 21 (vi).

***Oxytropsis jonesii* Barneby.** Jones Oxytrope. Acaulescent, densely pulvinate-caespitose; pubescence basifixed, villous-pilose; leaves 0.7–3 cm long; leaflets 1–7, 2–11 mm long, 1–3.5 mm wide, lanceolate to lance-oblong, pilose to strigose on both surfaces, quite sessile; scapes 0–3.5 cm long, villous-pilose; racemes 1- to 5-flowered, the flowers ascending at anthesis, the axis not elongating in fruit; bracts pilose; flowers (11) 14–16.5 mm long, pink-purple; calyx 7.5–9.5 mm long, the tube shortly cylindric, 4.5–7 mm long, the teeth 1.5–3 mm long, triangular to subulate; pods sessile or subsessile, erect, bladdery-inflated, 14–25 mm long 8–13 mm wide (when pressed), semi-bilocular, villous-pilose. Ponderosa pine, western bristlecone pine, and mixed desert shrub communities, on Flagstaff Limestone, Pink Limestone member of Wasatch Formation, and on Green River Shale Formation, at 1930 to 2430 m in Emery, Garfield (type from Red Canyon), and Uintah cos.; endemic. The Jones oxytrope is closely allied to *O. oreophila* with which it is sympatric at the type locality; 16 (v).

***Oxytropis lambertii* Pursh.** Lambert Locoweed. [*O. lambertii* var. *bigelovii* Gray; *Aragallus bigelovii* (Gray) Greene; *Astragalus lambertii* var. *bigelovii* (Gray) Tidestr.; *Aragallus metcalfei* Greene; *Aragallus knowltonii* Greene; *Aragallus patens* Rydb.; *O. patens* (Rydb.) A. Nels.; *O. bilocularis* A. Nels.]. Caespitose, acaulescent, (10) 14–50 cm tall; pubescence malpighian, strigose; stipules pilose; leaves 3–24 cm long; leaflets 7–13, 7–45 mm long, 2–8 mm wide, lanceolate to oblong or linear; scapes 4–28 cm long, strigose; racemes 8- to 40-flowered, the flowers ascending at anthesis, the axis 3–23 cm long in fruit; bracts strigose; flowers 17–25 mm long, pink-purple; calyx 6.5–10 mm long, the cylindric tube 4.5–7.5 mm long, the teeth 1.5–4.5 mm long, subulate; pods sessile or shortly stipitate, erect or ascending at maturity, cylindroid to lance-acuminate in outline, the body 15–27 mm long, 2.5–6 mm thick, bilocular, strigose to strigulose. Mixed desert shrub, pinyon-juniper, sagebrush, and grass communities at 1230 to 2730 m in Carbon, Duchesne, Emery, Garfield, Kane, San Juan, Sanpete, Sevier, Wasatch, and Wayne cos.; the species from Saskatchewan and Manitoba south to Arizona, New Mexico, and Texas. Our material belongs to **var. *bigelovii* A. Gray,** which occurs from Wyoming south to Arizona and New Mexico. In other places where *O. lambertii* contacts *O. sericea*, hybrid swarms of great variability and beauty occur. No such extensive hybrid populations are known for Utah, possibly becauuse the points of contact between these species are few or non-existent; 51 (xii).

***Oxytropis multiceps* Torr. & Gray.** Rocky Mountain Oxytrope. [*Spiesia multiceps* (Torr. & Gray) Kuntze; *Aragallus multiceps* (Torr. & Gray) Heller; *Astragalus bisontum* Tidestr.; *O. multiceps* var. *minor* A. Gray; *Aragallus multiceps* var. *minor* (A. Gray) A. Nels.; *Aragallus minor* (A. Gray) Cockerell ex Daniels; *O. minor* (A. Gray) Cockerell; *Astragalus bisontum* var. *minor* (A. Gray) Tidestr.]. Caespitose, acaulescent, pulvinate; pubescence basifixed, silky-pilose; stipules amplexicaul but distinct, silky-pilose; leaves 1–5 cm long; leaflets 5–9, 3–13 mm long, 1–4 mm wide, lanceolate to elliptic, oblong, or oblanceolate, silky-pilose; scape 1–4 cm long, long-villous; racemes 1- to 4-flowered, the flowers ascending-spreading at anthesis, the axis to 0.5 cm long in fruit; bracts thinly pilose; flowers 17–24 mm long, bright pink-purple; calyx 7–13 (20) mm long, the tube swollen at anthesis, becoming bladdery-inflated and investing the fruit at maturity, 5.5–10 mm long (8–18 mm in fruit), the teeth 2–3 mm long, triangular-subulate; pods included within the swollen calyx, stipitate, the stipe 0.5–1.5 mm long, the ovoid-ellipsoid body 6–10 mm long, 3–5 mm wide, subunilocular, short-villous. Pinyon-juniper and ponderosa pine communities at 1830 to 2270 m in Daggett Co.; Wyoming, Colorado, and Nebraska; 2 (0).

Oxytropis oreophila **A. Gray.** Mountain Oxytrope. Caespitose, acaulescent, often densely pulvinate, 1–14 (23) cm tall; pubescence basifixed, silky-pilose; stipules silky-pilose; leaves 0.5–8.5 cm long; leaflets (5) 7–17, 1–15 mm long, 0.5–4 mm wide, lanceolate, elliptic, oval, or ovate, pilose; scapes 0–12 (21) cm long, pilose to hirsute; racemes (1) 2- to 12-flowered, the flowers ascending-spreading at anthesis, the axis to 1 cm long in fruit; bracts pilose; flowers 6–12.5 mm long, pink to pink-purple or white; calyx 4.5–8 mm long, the tube 3.2–5.5 mm long, campanulate to short-cylindric, the teeth 1.3–2.5 mm long, subulate; pods sessile, bladdery-inflated, (7) 9–17 mm long, 5–14 mm wide (when pressed), subunilocular, hirsutulous to villous. Two more or less distinctive, but only arbitrarily separable varieties are present in Utah.

1. Plants densely pulvinate-caespitose; leaves 0.5–2 cm long, the leaflets mostly 2–5 mm long; pods 10 mm long or less, and less than 6 mm wide; flowers 9.5 mm long or less .... *O. orephila* var. *juniperina*

— Plants densely to loosely pulvinate-caespitose; leaves often more than 2 cm long, the leaflets commonly more than 5 mm long; pods 9–17 mm long, more than 6 mm wide; flowers commonly 10–12.5 mm long. .... *O. oreophila* var. *oreophila*

Var. ***juniperina*** **Welsh var. nov.** *Oxytropis oreophila* var. *oreophila* aemulans sed differt dense caespitosi-pulvinatis, foliis brevissimis, leguminibus brevissimis et angustis, et floribus brevissimis. Holotype: Utah, Wayne Co., ca 1 mile east of Bicknell, at 2200 m on Carmel formation, in pinyon-juniper woodland, Welsh & Moore 13828, 30 June 1976 (BRY). Paratypes; Utah, Wayne Co., do, Welsh & Moore 13831, 30 June 1976 (BRY); do, Atwood 1863, 18 June 1969 (BRY). Material of the *Juniperina* phase has long been recognized. Gray (Proc. Amer. Acad. 20:3, 1884) alluded to a specimen by Ward (574 GH, US), from Rabbit Valley (Loa-Bicknell vicinity), Utah, as a possible variety of *O. oreophila* or a related species "with flowers immersed in tufts of foliage." It is a xeric phase of *O. oreophila*, which passes by degree in to var. *oreophila*. Other xeric phases fail to demonstrate the morphological features of these striking plants, and the trend seems worth recognition from a taxonomic standpoint; 5 (iii).

Var. ***oreophila.*** [*Spiesia oreophila* (Gray) Kuntze; *Aragallus oreophilus* (Gray) A. Nels.; *Astragalus oreophilus* (Gray) Tidestr.; *Astragalus munzii* Wheeler.] Alpine tundra, ridge tops, meadows, spruce-fir, ponderosa pine, pinyon-juniper, and less commonly in mixed desert shrub communities, on limestone, volcanic gravels, beach gravels, and sands, at 1700 to 3350 m in Beaver, Garfield, Iron, Kane, Piute, Sanpete, and Wayne cos.; California, Nevada, Arizona, and New Mexico; 67 (xiv).

Oxytropis parryi **A. Gray.** Parry Oxytrope. [*Spiesia parryi* (A. Gray) Kuntze; *Aragallus parryi* (A. Gray) Greene; *Astragalus parryanus* Tidestr., not *A. parryi* A. Gray.] Caespitose, acaulescent, 2–11 cm tall; pubescence basifixed, silky-pilose; leavse 1.5–7 cm long; leaflet 7–17, 2–9 (12) mm long, 0.8–3 mm wide, oblong to elliptic or lanceolate, pilose; scapes 1.2–8 (10) cm long, pilose; racemes 1- to 3 (4) -flowered, the flowers erect or ascending, the axis 0.5–1 cm long in fruit; bracts pilose; flowers 7.5–12 mm long, pink-purple; calyx 5–8 mm long, the tube 3–5.5 mm long, campanulate to short-cylindric, the teeth 1.5–2.5 mm long, triangular-subulate; pods erect, sessile, oblong to lance-ovoid, 13–22 mm long, 4–8 mm thick, bilocular or nearly so, pilosulous. Alpine tundra, ridge tops, and meadows at 2700 to 3770 m in Beaver, Carbon, Garfield, Grand, Juab, Piute, San Juan, and Wasatch cos.; Idaho, Wyoming, California, Colorado, and New Mexico. The Parry oxytrope is difficult to distinguish in flower from *O. oreophila*, especially from specimens of that species with fewer than five flowers. The fruit is definitive; 11 (v).

Oxytropis sericea **Nutt. in Torr. & Gray.** Silky or White Locoweed. [*O. lambertii* var. *sericea* (Nutt.) A. Gray; *Spiesia lambertii* var. *sericea* (Nutt.) Rydb.; *Aragallus lambertii* var. *sericeus* (Nutt.) A. Nels.; *Aragallus majusculus* Greene, type from the Mt. Ellen Henry Mts.] Caespitose, acaulescent, 13–32 cm tall, pubescence basifixed, silky-pilose; stipules pilose to subtomentose; leaves 3.5–21 cm long; leaflets 9–23, 4–32 (40) mm long, 1.5–10 mm wide, lanceolate to oblong elliptic, or ovate, pilose; scapes 7–26 cm long, pilose; racemes 6- to 27-flowered, the flowers ascending to spreading, the axis 1.5–12 cm long in fruit; bracts pilose; flowers 15–26 mm long, white or tinged with purple; calyx 8–12 mm long, the tube cylindric, the teeth triangular to subulate; pods erect, sessile, the body subcylindric to ovoid-oblong, 10–25 mm long, 4–7.5 mm thick, bilocular or nearly so, strigose or pilosulous. Sagebrush, pinyon-juniper, and grassland (rarely mixed desert shrub) communities at 1670 to 3350 m in Box Elder, Carbon, Daggett, Duchesne, Emery, Garfield, Kane, Piute, Summit, and Wayne cos.; the species from the Yukon southward to Nevada, New Mexico, and Oklahoma. Our materials belong to var. ***sericea,*** which occurs from Montana, Idaho, and Souta Dakota, south to Nevada, New Mexico, and Oklahoma; 38 (vii).

Oxytropis viscida **Nutt.** Viscid Locoweed. [*O. campestris* var. *viscida* (Nutt.) S. Wats.; *Spiesia viscida* (Nutt.) Tidestr.] Caespitose, acaulescent, 4–18 cm tall; pubescence basifixed, spreading-hairy; stipules glabrous dorsally, commonly prominently glandular; leaves 2–17 cm long; leaflets 19–39 or more, 1.5–20 mm long, 1–5 mm wide, oblong to lanceolate or elliptic, glabrate to glabrous on both sides, sometimes glandular; scapes 2–12.5 cm long, spreading-hairy; racemes 3- to 20-flowered, the flowers spreading-ascending, the axis 2–7 cm long in fruit; bracts glandular; flowers 11–19 mm long, whitish, lilac, or pink-purple; calyx 5–11 mm long, the shortly cylindric tube 4–7 mm long, the teeth 1.5–3.5 mm long, triangular-subulate, commonly glandular; pods erect, sessile, ovoid to subcylindric, 8–20 mm long, 4–5 mm thick, bilocular, glandular. Montane meadows, shrublands, and open woods at 2430 to 3050 m in Emery, Salt Lake, Sanpete, Sevier, Utah, and Wayne cos.; Alaska east to Gaspé and south to California, Nevada, Colorado, and Minnesota. Our material belongs to var. *viscida.* This is a portion of a circumboreal complex with great variation. Utah materials demonstrate two of the extreme phases of that variety. Naming of the phases within the species would lead to an endless entanglement. Thus, the whitish flowered plants from Emery, Sanpete, and Sevier cos., are considered as a minor element in this evidently polygenetic and certainly polymorphic series; 14 (iv).

PARRYELLA Torr. & Gray ex A. Gray

Unarmed shrubs; leaves alternate, pinnate, with numerous leaflets, glandular-dotted; stipules subulate, caducous; peduncles opposite the leaves; flowers in loose spicate racemes or panicles; calyx turbinate-campanulate, 10-ribbed near the base, 5-lobed; petals lacking; stamens 10, the filaments distinct, inserted on the hypanthium; pods 1-seeded (2-ovuled), indehiscent, obliquely obovoid, glandular-dotted, exserted from the calyx.

REFERENCES

RYDBERG, P. A. 1919. *Parryella.* pp. 25–26. In: Rydberg, P. A. Fabaceae-Psoraleae. N. Amer. Fl. 24:1–64.

Parryella filifolia **Torr. & Gray ex A. Gray.** Narrow-leaf Dunebroom. Shrubs to 15 cm tall or more, often partially buried in sand, the branchlets strigose and with mammiform glandular protuberances; stipules 1–2 mm long, chestnut-brown, fragile; leaves 3.5–13 cm long; leaflets 8–40, 1–21 mm long, linear, all involute, strigose to glabrate and glandular on the visible surface; peduncles 0–1 cm long; racemes 4–10 cm long, the main ones often branched near the base, forming panicles, 35- to 90-flowered, the axis not much elongating in fruit; bracts reduced to gland-tipped vestiges; calyx 2.6–3.1 mm long, 10-ribbed near the base, the tube opaque, the teeth 0.2–0.5 mm long, ciliate; flowers 5–6.5 mm long in anthesis, the stamens long-exserted; pods short-stipitate, the body 5–6.5 mm long, 2.5–3 mm wide, the pilose style base persistent, glabrous, glandular-punctate. Stabilized dune sands at 1470 to 1570 m astride the Grand-San Juan co. line, and previously known from along the San Juan River near the present upper reaches of Lake Powell; New Mexico and Arizona; 5 (iv).

PETERIA A. Gray

Perennial, caulescent, from a subterranean caudex arising from deep-seated tuberous roots; leaves alternate, odd-pinnate; stipules only slightly adnate to the petiole base, spinescent; flowers papilionaceous, borne in terminal racemes, each subtended by a bract, or the lowermost flower sometimes axillary; bracteoles 0; calyx 5-toothed; petals 5, whitish to ochroleucous, rarely pinkish; stamens 10, diadelphous; style hairy at apex; pods narrowly oblong, straight, few- to several-seeded, laterally compressed, dehiscent, the valves coiling upon dehiscence.

Peteria thompsonae **S. Wats.** Thompson Peteria. [*P. nevadensis* Tidestr.]. Perennial, 11–48 cm tall; pubescence basifixed, of flattened appressed hairs; stems erect to sprawling; stipular spines 1.8–6.5 mm long; leaves 4–18 cm long; leaflets 9–27, 6–17 mm long, 3–11 mm wide, elliptic to ovate, oblong to oval, strigose on both sides or glabrate above; peduncles 0–4 cm long; racemes 5- to 44-flowered, the flowers ascending at anthesis, the axis 6–18 cm long in fruit; bracts 5–9 mm long, stipitate-glandular; pedicels 1–5 mm long, strigulose and stipitate-glandular; calyx 11–16.2 mm long, the tube 6.5–8 mm long, short-cylindric, stipitate-glandular, the teeth 3.8–9 mm long, lance-subulate; flowers 18–22 mm long, whitish to ochroleucous, rarely pinkish; pods descending, stipitate, the stipe to 11 mm long, the body 48–55 (70) mm long, 5–7 mm wide, glabrous, more or less constricted between the seeds. Pinyon-juniper and mixed desert shrub communities at 1230 to 1870 m in Emery, Grand, Juab, Kane, San Juan, and Washington co.; Arizona, Nevada, and Idaho. The type specimen was collected by Mrs. Ellen Thompson, sister of John Wesley Powell, at Kanab, where she lived in 1872. This is a singular and striking plant; 16 (v).

PHASEOLUS L.

Annual herbs, from a taproot; leaves alternate, pinnately trifoliolate; stipules herbaceous, distinct; flowers papilionaceous, axillary or in axillary racemes, each subtended by a bract; bracteoles 2, attached at base of calyx; calyx 5-toothed; petals 5, pink to purplish or white; stamens 10, diadelphous; ovary few- to several-ovuled, the style twisted or coiled in the keel, bearded towards the apex, the stigma oblique; pods linear to oblong, laterally flattened to subterete, the valves coiling upon dehiscence.

Phaseolus vulgaris **L.** Kidney Bean. Annual, 30–200 cm tall or more, clump-forming or twining and vine-like; pubescence basifixed, villosulous or finally glabrate; petioles 4–20 cm long; leaflets 3, stipelate, commonly 40–100 mm long and 20–80 mm wide, ovate to lanceolate, pilosulous to villosulous on both sides, mainly along the veins; peduncles 0–2 cm long; racemes few-flowered; flowers 12–16 mm long; bracteoles ovate-lanceolate, prominently veined; pods slender, subterete to flattened, most 6–15 cm long. This is the table bean of commerce. It is cultivated widely, escaping commonly, but hardly persisting; native of the New World (?). Additional species are present in the cultivated flora of the state, but the extent is unknown, and they are here excluded. Among them are the scarlet runner bean (*P. coccineus* L.) and the lima bean (*P. limensis* Macf.); 2 (i).

PISUM L.

Plants herbaceous, annual, from a taproot; stipules prominent, larger than the leaflets, semi-sagittate to ovate or reniform; stems clambering, not winged; leaves alternate, even-pinnate, the terminal extension of the rachis forming prehensile tendrils; racemes axillary, pedunculate, 1- to few-flowered; stamens 10, diadelphous; style laterally compressed, bearded along the ventral edge; pods 1-loculed, oblong in outline, several-seeded, the valves coiling upon dehiscence.

Pisum sativum **L.** Garden Pea. Plants 20–200 cm long or more, sprawling or clambering, the stems merely angled, glabrous; stipules foliaceous, larger than the leaflets; leaflets 4–6, elliptic to ovate to oblong-lanceolate, 9–60 mm long, 6–40 mm wide, glabrous; tendrils with 1–3 pairs of lateral branches, prehensile; flowers 1–3 per raceme, white, red, or bicolored, 18–30 mm long; calyx 12–18 mm long, the teeth longer than the tube; pods commonly 4–10 cm long, glabrous. Cultivated pea of commerce, widely grown, escaping but not persisting; introduced from Eurasia. Several horticultural forms are grown, mostly with white flowers. 2 (i).

PROSOPIS L.

Armed shrubs or small trees; leaves alternate, bipinnate, with an obscure gland between the lower pair of pinnae; leaflets several to numerous; stipules small, or modified as spines; flowers perfect, borne in spikelike racemes, yellowish to ochroleucous; calyx 5-toothed; corolla regular, the 5 petals distinct or nearly so; stamens 10, distinct, exserted, the anthers terminally glandular; ovary pubescent, sessile or stipitate, the stigma concave; pods indehiscent, narrowly oblong and more or less constricted between the seeds or spirally coiled.

REFERENCES

JOHNSTON, M. D. 1962. The North American Mesquites, *Prosopis* Sect. Algarobia (Leguminosae). Brittonia 4:72–90.

1. Leaflets 5–8 pairs, mostly less than 10 mm long; pods coiled spirally into a woody cylinder .... *P. pubescens*

— Leaflets 10–18 pairs or more, often exceeding 10 mm long; pods narrowly oblong, straight or nearly so .... *P. glandulosa*

Prosopis glandulosa Torr. Mesquite. [*P. juliflora* authors, not (Sw.) DC.; *P. chilensis* authors, not (Mol.) Stuntz]. Armed shrubs or broad-crowned trees, commonly 3–5 m tall; leaves petiolate, the rachis produced as a spine; pinnae 2; leaflets 7–17 pairs, oblong to narrowly oblong, 7–38 mm long, 1–4 mm wide, glabrous on both sides, sometimes ciliate; spines nodal but not stipular, single or paired, 3–35 mm long or more; stipules inconspicuous, subulate; flowers in yellowish to greenish spikes, clustered from spur branches, ascending to declined; ovary pilose; pods stipitate, the stipe 5–8 mm long, the body narrowly oblong to linear, often curved, subterete to somewhat flattened, mostly 100 to 200 mm long, a bony endocarp around each seed. Terraces and bars at 670 to 1170 m in Washington Co.; the species from California, Nevada, Arizona, New Mexico, Kansas, Oklahoma, Texas, and southward. Our specimens belong to var. ***torreyana*** **(Benson) M. C. Johnston** (*P. juliflora* var. *torreyana* Benson), with distribution from California, Arizona, New Mexico, and Texas southward. In the herbarium of the University of Utah (UT) there is a specimen of mesquite labeled as collected in a vacant lot in North Salt Lake; whether accidental or cultivated, is not known; 17 (i).

Prosopis pubescens **Benth.** Screwbean. [*P. odorata* Torr. & Frem. in Frem.; *Strombocarpa pubescens* (Benth.) A. Gray; *S. odorata* A. Gray.] Armed shrubs or small trees with slender branches, commonly 2.5–3.5 m tall; leaves shortly petiolate, the rachis produced as a spine; pinnae 2 (rarely 4); leaflets 5–8 pairs, elliptic to oblong, puberulent to glabrate; spines paired at nodes, apparently stipular, mostly 5–25 mm long; flowers in clusters or solitary, yellowish spikes; ovary villous; pods tightly coiled into a woody cylinder, 30–50 mm long, 4–6 mm thick. Benchlands, slopes, and terraces along drainages at 730 to 900 m in Washington Co.; California, Nevada, Arizona, New Mexico, Texas, and Mexico; 9 (i).

PSORALEA L.

Perennial herbs, unarmed, from rhizomes or tuberous roots; leaves alternate, palmately compound, the leaflets 3–5, glandular-dotted; stipules triangular to subulate; flowers in axillary racemes or spike-like racemes; calyx subcylindric to campanulate, 5-lobed; corolla papilionaceous; stamens 10, diadelphous (rarely all connate); petals bluish or purplish to lavender or white; pods 1-seeded, indehiscent or irregularly so, included in the calyx or slightly exceeding it.

REFERENCES

MATTHEWS, E. H. 1969. A preliminary revision of the genus *Psoralea* in Utah. Unpublished Mss. Brigham Young University. 42 pp.

OCKENDON, D. J. 1965. A taxonomic study of *Psoralea* subgenus Pediomelum (Leguminosae). Southwestern Nat. 10:81–124.

TOFT, C. A. AND S. L. WELSH. 1972. A revision of the *Psoralea lanceolata* complex (Leguminosae). Great Basin Nat. 32:76–87.

1. Plants strongly caulescent, commonly 25–100 cm tall, arising from rhizomes; leaves mainly 3-foliolate (except in *P. tenuiflora*); leaflets narrowly obovate to oblanceolate or linear; bracts of inflorescence inconspicuous 2

— Plants subacaulescent to short-caulescent, mostly shorter than 25 cm, arising from tuberous roots or thickened rhizomes; leaves mainly 5-foliolate (except in *P. pariensis*); leaflets obovate to sub-orbicular; bracts of inflorescence conspicuous 4

2(1). Peduncles 15–40 cm long or more; leaves few, mostly deciduous by anthesis, the leaflets sharply acuminate; plants of southeastern Utah .... *P. juncea*

— Peduncles mainly shorter than 15 cm; leaves numerous, persisting through the season, the leaflets obtuse to rounded or cuspidate; distribution various 3

3(2). Plants commonly 40–100 cm tall, at least some leaves 4- to 5-foliolate; flowers mainly indigo; plants of western Kane, Washington, and Iron cos. .... *P. tenuiflora*

— Plants often less than 40 cm tall, all leaves commonly 3-foliolate; flowers white to purple; plants widespread in Utah .... *P. lanceolata*

4(1). Plants definitely caulescent, or if acaulescent (as occasionally in *P. epipsila*), then leaflets glabrous or glabrate above 5

— Plants acaulescent to short-caulescent; leaflets definitely pubescent above 6

5(4). Leaflets conspicuously bicolored, cinerous beneath, bright green and glabrous to glabrate above (except along some veins); plants known only from southern Kane Co. and adjacent Arizona .... *P. epipsila*

— Leaflets dull-green beneath, green above, pubescent as above; plants of central eastern Utah .... *P. aromatica*

6(4). Leaflets commonly 3, strongly white strigose along the veins above; plants of the Paunsagaunt and Paria regions .... *P. pariensis*

— Leaflets commonly 5, uniformly strigose above, or glabrous, or thinly strigose along the veins; plants of various distribution 7

7(6). Petioles and peduncles appressed or ascending pubescent; plants rather widespread in eastern Utah. .... *P. megalantha*

— Petioles and peduncles retrorsely hairy; plants of Washington Co. .... *P. mephitica*

Psoralea aromatica **Payson.** Paradox Breadroot. [*P. rafaelensis* M. E. Jones, type from LaSal Mts.; *P. rafaelensis* var. *magna* M. E. Jones, type from the San Rafael Swell.] Caulescent, 8–15 (20) cm tall, from slender subterranean caudex branches arising from deep-seated tuberous roots; stems with 2–4 (5) elongated internodes, strigose to strigulose; leaves mainly 5-foliolate; petioles 1.2–8 cm long, pubescent like the stems; leaflets 6–26 mm long, 3–16 mm wide, cuneate-obovate, gray-green, strigulose, and punctate beneath, yellow-green, punctate, and strigose overall or only along the veins above; stipules scarious, 2–9 mm long; peduncles 0.2–0.5 cm long; racemes 3- to 7- flowered, 1–2 cm long; pedicels 1–2.5 mm long; bracts lanceolate, 4–7 mm long; flowers 10–13 mm long, the banner, wings, and keel more or less suffused with purple; calyx 10–11 mm long, the tube 3–4 mm long, strongly gibbous, the lower tooth 5–7 mm long, about twice as broad as the lower lateral ones; pods to 15 mm long. Pinyon-juniper woodland and mixed desert shrub communities at about 1530 m in Emery and Grand cos.; Paradox Basin, Colorado, a middle Navajo Basin endemic; 8 (2).

Psoralea epipsila **Barneby.** Kane Breadroot. Subacaulescent or short-caulescent, 3.5–10.5 cm tall, from slender subterranean caudex branches arising from deep-seated tuberous roots; stems with 2 or 3 elongated internodes, strigose to ascending hairy; leaves mainly 5-foliolate; petioles 0.8–5 cm long, pubescent like the stems; leaflets 5, 8–25 mm long, 3–15 mm wide, obovate, grayish, strigulose, and punctate beneath, bright yellow-green, punctate and glabrous to thinly strigose above (especially along the veins); peduncles to 5 cm long; racemes 2–4 cm long; pedicels about 3 mm long; bracts broadly lanceolate, 10–13 mm long; flowers 11–14 mm long, the banner, wings, and keel pale violet; calyx 11–14 mm long, the tube 5–6 mm long, strongly gibbous, the lower tooth about 8 mm long, the upper ones shorter and narrower; pods 1-seeded. Pinyon-juniper woodland at about 1670 m on Chinle and Moenkopi formations in Kane Co., and in adjacent Arizona; 2 (0). The Kane breadroot is still imperfectly understood, even though the first collection was taken by M. E. Jones in 1890. Many more collections are necessary before adequate descriptions and relationships can be drawn. This is a Mohave Strip endemic; 2 (0).

Psoralea juncea **Eastw.** Rush Scurfpea. [*Psoralidium junceum* (Eastw.) Rydb.] Caulescent, 48–90 cm tall, from a rhizome; stems with 5 or more elongated internodes, strigose; leaves commonly 3-foliolate, often deciduous by anthesis; petioles 1.4–7 cm long, pubescent like the stems; leaflets 3, 19–44 mm long, 3–7 mm wide, oblanceolate to eliptic, acuminate apically, strigose and glandular on both surfaces, greenish; stipules acuminate, strigose; peduncles (8) 11–48 cm long; racemes 7- to 20-flowered, 5–11 cm long; bracts lance-acuminate, glabrous dorsally, 1.5–2.5 mm long, deciduous; flowers 4.2–5.8 mm long, the petals indigo; calyx 2.7–3.4 mm long, the tube 1.3–2.5 mm long, campanulate, not especially gibbous, the lower tooth 0.7–1.4 mm long, longer than the others; pods 1-seeded, densely silky-villous. Stabilized dunes and other sandy sites at 1200 to 1370 m in Garfield, Kane, and San Juan cos.; Coconino Co., Arizona; a Glen Canyon–San Juan endemic; 21 (iv).

Psoralea lanceolata **Pursh.** Dune Scurfpea. Caulescent, 15–68 cm tall, from a rhizome, clump-forming; stems with 5 or more elongated internodes, glabrous or strigose; leaves commonly 3-foliolate, persistent at flowering; petioles 0.8–3 cm long, strigose to glabrate; leaflets 3, 14–50 mm long, 0.5–9 mm wide, oblanceolate below becoming linear upwards, obtuse to acute or cuspidate, sparingly strigose on both sides or glabrous above, yellow-green; stipules lance-attenuate, 3–16 mm long; peduncles 3.3–24 cm long; racemes 5- to 41-flowered, 1.2–17 cm long; bracts ovate to elliptic or lanceolate, glabrous dorsally, 1.3–2.8 mm long, persistent, flowers 4.8–6.3 mm long, blue, white, or bicolored; calyx 1.6–2.8 mm long, the tube 1.3–2 mm long, campanulate, not especially gibbous, the lower tooth 0.2–0.8 mm long, not much larger than the others; pods 1-seeded, conspicuously glandular. Three rather distinctive but apparently intergrading varieties are present in Utah.

1. Racemes lax, 25-170 mm long at anthesis, the flower nodes widely separated, often with 2 or 3 flowers per node; blue flower color predominating; plants of southeastern Utah .... *P. lanceolata* var. *stenophylla*

— Racemes compact to moderately lax, 12–55 mm long at anthesis, the flower nodes seldom widely separated or mainly with more than 3 flowers per node; blue and white flowers variably abundant; plants of various distribution 2

2(1). Racemes (12) 27–55 mm long, with (17) 27–41 flowers; plants of the Great Basin.. *P. lanceolata* var. *stenostachys*

— Racemes 10–25 (28) mm long, with 5–24 flowers; plants of the Colorado Basin .... *P. lanceolata* var. *lanceolata*

Var. *lanceolata*. Plains Scurfpea. [*Psoralidium lanceolatum* (Pursh) Rydb.; *P. elliptica* Pursh; *Lotodes ellipticum* (Pursh) Kuntze; *P. laxiflora* Nutt. ex Torr. & Gray; *P. micrantha* A. Gray ex Torr.; *Psoralidium micranthum* (A. Gray) Rydb.] Sand dunes and other sandy sites at 1230 to 1770 m in Daggett, Garfield, Grand, Kane, Uintah, Washington, and Wayne cos.; Washington and Saskatchewan south to California, Arizona, New Mexico, and Oklahoma; 36 (viii).

Var. *stenophylla* (Rydb.) Toft & Welsh. Canyon Scurfpea. [*P. stenophylla* Rydb.; *Psoralidium stenophyllum* (Rydb.) Rydb.] Sandy sites at 1270 to 1830 m in Emery, Garfield, Grand (type from Wilson Mesa), Kane, San Juan, and Wayne cos.; endemic; 26 (xiii).

Var. *stenostachys* (Rydb.) Welsh comb. nov. based on *Psoralea stenostachys* Rydb., Bull. Torrey Bot. Club 42:46. 1913. Basin Scurfpea. [*Psoralidium stenostachys* (Rydb.) Rydb.] Dunes and other sandy sites in Juab, Kane, Millard, Salt Lake, Tooele (type from Government Well) and Weber cos.; endemic. Specimens from Salt Lake and Weber cos. are placed here tentatively because of the nature of the existing materials. The plants have not been collected in those counties in recent times, and they might well be extinct. The question of their varietal status might therefore be moot; 27 (ii).

***Psoralea megalantha* Woot. & Standl.** Large-flowered Breadroot. [*Pediomelum megalanthum* (Woot. & Standl.) Rydb.] Subacaulescent to short-caulescent, 4–15 cm tall, from slender subterranean caudex branches arising from deep-seated tuberous roots; stems with 0–3 elongated internodes, incurved-strigose or with a few (rarely most) hairs spreading-ascending; leaves mainly 5 (8) -foliolate; petioles 1.2–9.5 cm long, pubescent like the stems or more commonly mainly spreading-hairy; leaflets 9–34 mm long, 4–23 mm wide, cuneate-obovate to subrhombic, gray-green, strigulose, and punctate beneath, yellow-green, punctate, and strigose overall above; stipules scarious, 2–15 mm long; peduncles 1.4–5 cm long; racemes mainly 6- to 24-flowered, 2–5 cm long; pedicles 1.5–5 mm long, bracts commonly bidentate, lance-ovate, 3–12 mm long; flowers 12.5–21 mm long, the banner, wings, and keel commonly purple or suffused with purple; calyx 12.5–18.5 mm long, the tube 5.5–8 (9) mm long, strongly gibbous, the lower tooth 4–9 (10) mm long, only somewhat broader than the lateral ones; pods included in the calyx. Mixed desert shrub, juniper-pinyon woodland, and blackbrush communities at 1430 to 1830 m in Duchesne, Grand, San Juan, Uintah, and Wayne cos.; Colorado and New Mexico. The plants of large-flowered breadroot are quite uniform, with two exceptions. Those from San Juan Co. tend to produce stems with elongate internodes, some of them with dense ascending-spreading pubescence. A collection from eastern Wayne Co. has flowers only 12.5 mm long. Much more material is necessary before decisions as to status of these variations will be possible; 16 (viii).

***Psoralea mephitica* S. Wats.** Skunk Breadroot. [*Pediomelum mephiticum* S. Wats.) Rydb.; *Pediomelum retrorsum* Rydb.; *P. retrorsa* (Rydb.) Tidestr. in Tidestr. & Kittell; *P. mephitica* var. retrorsa (Rydb.) Kearney

& Peebles.] Acaulescent to subacaulescent, 4.5–15 cm tall, from slender subterranean caudex branches arising from deep-seated tuberous roots; stems lacking or with very short internodes above ground, retrorsely hairy; leaves mainly 5-foliolate; petioles 3.2–12 cm long, retrorsely hairy; leaflets 11–35 mm long, 4–28 mm wide, obovate to broadly so, gray-green, strigose overall, and punctate beneath, green to yellow-green, strigose overall (more densely along veins), and punctate above; stipules scarious, 4–12 mm long; peduncles 2–6 cm long; racemes mainly 12- to 35-flowered, 1.5–4.5 cm long; pedicels 1.5–3.5 mm long; bracts mainly not bidentate, elliptic-obovate, 5–12 mm long; flowers 10.5–12.8 mm long, the banner whitish or yellowish, the wings and keel purple or suffused with purple; calyx 9–12.5 mm long, the tube 3.5–4.5 mm long, strongly gibbous at the base, the lower tooth 4.5–9 mm long, about twice as broad as the others; pods included in the calyx. Blackbrush and pinyon-juniper communities at 1470 to 1700 m in southeastern Washington Co.; Arizona, Nevada, and California. This species was described by Sereno Watson simultaneously with *P. castorea* (Proc. Amer. Acad. 14:291. 1879). The type locality of both of these taxa is cited in the original descriptions as "near Beaver City, S. Utah." The type collections were both by Dr. E. Palmer (No. 96 for *P. castorea*, and No. 97 for *P. mephitica*). Palmer (Amer. Nat. 12:601. 1878) in describing the use of these plants by Indians (as food) noted that *P. castorea* S. Wats. "grows in exposed sandy localities between Beaver Dams, Arizona, and St. Thomas, Nevada." [sic]. Of *P. mephitica*, Palmer (l.c.) notes that "it is abundant on the low places between the hills southeast from St. George, Southern Utah, and the Pah-Utes resort there to collect its roots" (sic). Thus, the type localities can be inferred as being in northwestern Arizona or south-eastern Nevada for *P. castorea*, and in the hills to the southeast of St. George for *P. mephitica*. There is no evidence to support the idea that *P. castorea* was ever collected in Utah, and it is herein excluded. Finally, no specimen of any of the breadroot psoraleas is known from the Great Basin portion of Utah in modern collections, and it seems likely that none was taken there in the past; 6 (0).

Psoralea pariensis **Welsh & Atwood** in Welsh, Atwood, & Reveal. Paria Breadroot. Acaulescent or subacaulescent, 2–9 cm tall, from slender subterranean caudex branches arising from deep-seated tuberous roots; stems lacking or with very short internodes above ground, strigose; leaves mainly 3-foliolate; petioles 1.3–7 cm long, strigose; leaflets 9–25 mm long, 7–22 mm wide, obovate or orbicular, cuneate, rounded to truncate or emarginate apically, gray-green, glandular, and strigose beneath, yellow-green, glandular and strongly strigose along veins above; stipules scarious, 4–10 mm long; peduncles 0.5–2.8 cm long, the hairs appressed to ascending; racemes mainly 6-to 15-flowered, 1–2.5 cm long; pedicels 1–3.8 mm long; bracts abruptly acuminate, 4–8 mm long; flowers 8.8–12.5 mm long, the banner cream to ochroleucous, the wings and keel purple or suffused with purple; calyx 8.6–11.4 mm long, the tube 3.3–4.6 mm long, more or less gibbous at the base, the lower calyx teeth 5.3–6.8 mm long, about twice broader than the others; pods included in the calyx, about 9 mm long. Ponderosa pine and juniper-pinyon woods at 1700 to 2430 m in Garfield (type from Bryce Canyon) and Kane cos.; endemic; 8 (ii).

Psoralea tenuiflora **Pursh.** Prairie Scurfpea. [*Psoralidium tenuiflorum* (Pursh) Rydb.; *P. obtusiloba* Torr. & Gray; *Psoralidium bigelovii* Rydb.; *P. bigelovii* (Rydb.) Tidestr.; *P. tenuiflora* var. *bigelovii* (Rydb.) Macbr.; *P. floribunda* Torr. & Gray; *Psoralidium floribundum* (Nutt.) Rydb.] Caulescent, 40–100 cm tall or more, forming large clumps; stems with 8 or more elongated internodes, strigose; leaves 3- to 5-foliolate, persistent at flowering; petioles 0.1–2.2 cm long, strigose to strigulose; leaflets 3–5, 6–40 mm long, 2–16 mm wide, oblanceolate throughout, mainly rounded to a cuspidate apex, gray-green and strigose beneath, yellow-green and glabrous or pubescent only along veins above; stipules scarious, 2–13 mm long, strigose; peduncles 0.5–7 cm long, or lacking, sometimes bracteate or some flowers axillary; racemes mainly 7- to

21-flowered, 9–5.9 cm long; bracts ovate-acuminate, glabrous dorsally, 1.5–2.5 mm long, persistent; flowers 4.5–6 cm long, the petals indigo; calyx 2.5–3.2 mm long, the tube 1.5–2 mm long, campanulate, not gibbous, the lower tooth 0.8–1.7 mm long, noticeably larger than the others; pods 1-seeded, glabrous, conspicuously glandular. Pinyon-juniper, sagebrush, and mountain brush communities at 1700 to 2200 m in Garfield, Iron, Kane, and Washington cos.; North Dakota and Montana southward to Arizona, Texas, and Mexico. The segregation of varieties from among our specimens seems unwarranted; 14 (iii).

PSOROTHAMNUS Rydb.

Shrubs, armed; leaves alternate, odd-pinnate, with 5 or more leaflets, glandular-dotted; stipules subulate or vestigial; peduncles opposite the leaves; flowers in lax racemes; calyx campanulate, 10-ribbed, 5-lobed; corolla papilionaceous, the petals all inserted on the hypanthium; stamens 9 or 10, monadelphous; petals mainly indigo; pods 1- to 2-seeded, indehiscent, exserted from the calyx. Note: Traditional treatments have placed the species herein recognized as *Psorothamnus* within an expanded *Dalea* (q.v.).

REFERENCES

RYDBERG, P. A. 1919. *Psorodendron* Rydb., and *Psorothamnus* Rydb. N. Amer. Fl. 24:41–48.

1. Branchlets densely reflexed-puberulent, bearing conspicuous yellow- to red-orange resinous glands 2

— Branchlets merely appressed-strigose, lacking glands or only obscurely glandular 3

2(1). Calyx lobes ovate to oval, obtuse to rounded, or the lowermost ovate-acute .... *P. thompsonae*

— Calyx lobes all lance-attenuate .... *P. polyadenius*

3(1). Calyx villous with contorted spreading hairs, the lateral teeth linear-lanceolate, quite as long as the tube; plants rare in Kane Co. .... *P. arborescens*

— Calyx strigose with appressed hairs or glabrate, the lateral teeth lance-attenuate, mostly shorter than the tube; plants locally common in Garfield, Kane, San Juan, and Washington cos. .... *P. fremontii*

***Psorothamnus arborescens* (Torr.) Barneby.** Beauty Indigo-bush. [*Dalea arborescens* Torr. in A. Gray; *Parosela arborescens* (Torr.) Heller; *Psorodendron arborescens* (Torr.) Rydb.; *Dalea amoena* S. Wats.; *Parosela amoena* (S. Wats.) Vail; *Psorodendron amoenum* (S. Wats.) Rydb.; *Parosela johnsonii* var. *pubescens* Parish; *Psorodendron pubescens* (Parish) Rydb.; *Dalea fremontii* var. *pubescens* (Parish) L. Benson; *D. amoena* var. *pubescens* (Parish) Peebles.] Armed shrubs, 4–10 dm tall or more; branchlets strigose to strigulose, sparingly glandular; stipules 1–2 mm long, subulate; leaves 1.4–3.8 cm long; leaflets 7–15, 1–10 (12) mm long, 0.7–1.5 mm wide, glandular beneath, strigose on both sides, linear to narrowly oblong, obtuse to rounded, the uppermost lateral leaflet often confluent with the terminal; peduncles 0.2–0.6 cm long, or the lowermost flower axillary; racemes 11- to 21-flowered, 1.8- to 4.5 cm long, the rachis pilosulous; bracts 1.5–3.5 mm long, lance-aristate, villosulous; calyx 8–10 mm long, the tube 3.8–4.8 mm long, definitely 10-ribbed, villous, the teeth 3.6–5.2 mm long, villous, not markedly differing in width; flowers 8.1–10.6 mm long, indigo; pods conspicuously glandular-dotted. Mixed desert shrub at 1230 to 1530 m in Kane Co.; Arizona and Nevada. Our material belongs to var. *pubescens* (Parish) Barneby; 3 (i).

***Psorothamnus fremontii* (Torr.) Barneby.**

Fremont Indigo-bush. [*Dalea fremontii* Torr. in A. Gray; *Parosela fremontii* (Torr.) Vail; *Psorodendron fremontii* (Torr.) Rydb.; *Dalea johnsonii* S. Wats., type from near St. George; *Parosela johnsonii* (S. Wats.) Vail; *Psorodendron johnsonii* (S. Wats.) Rydb.; *Parosela johnsonii* var. *minutifolia* Parish; *D. fremontii* var. *minutifolia* (Parish) L. Benson]. Armed shrubs, 5–15 dm tall or more; branchlets strigose, sparingly if at all glandular; stipules 0.3–1.5 mm long, fragile; leaves 1.8–6.5 cm long; leaflets (1) 3–9, 3–14 mm long, 0.8–6 mm wide, glandular beneath, strigose on both sides, linear to oblong or elliptic, obtuse to rounded, the uppermost often confluent with the rachis; peduncles 0–2.2 cm long, or some flowers axillary; racemes 7- to 41-flowered, 3.5–14.3 cm long, the rachis strigose to strigulose; bracts 0.8–1.8 mm long, lanceolate, glabrous or else foliose and with 1–5 leaflets; calyx 4.5–6.5 mm long, the tube 2.5–3.3 mm long, obscurely if at all 10-ribbed, appressed strigose to glabrate, the teeth 1.8–3.2 mm long, strigose, the upper markedly wider than the others; flowers 8.5–12 mm long, indigo; pods glandular-dotted. Blackbrush, creosote bush, mixed desert shrub, and (less commonly) pinyon-juniper communities at 730 to 2270 m in Garfield, Kane, San Juan, and Washington cos.; Nevada, Arizona, and California. The plants are strikingly beautiful, contrasting indigo-colored flowrs against grayish foliage; 44 (vii).

Psorothamnus polyadenius **(Torr.) Rydb.** Glandular Indigo-bush. Armed shrubs, 1.5–8 dm tall or more; branchlets velvety with retrorse short hairs, conspicuously glandular with yellow- or red-orange resinous glands; stipules vestigial or to 0.5 mm long; leaves 0.4–2.8 cm long; leaflets 5–13, 1.2–6.5 mm long, 1–5 mm wide, oval to obovate, or obcordate, glandular beneath, strigose on both sides, obtuse, rounded, or emarginate, the uppermost often confluent to each other and to the rachis; peduncles 0.8–2.7 cm long; racemes mainly 6- to 18-flowered, 2–5 cm long, the rachis retrorsely hairy; bracts 1–2.5 mm long, lanceolate, pilose; calyx 5.5–7.2 mm long, the tube 2.5–3.5 mm long, 10-ribbed, villous, the teeth 3.5–4.5 mm long, villous, lance-subulate, all about alike; flowers 7.5–9 mm long, indigo; pods glandular-dotted. Two rather distinctive varieties are present in Utah.

1. Branches strongly divaricate; leaflets flat, commonly less than 4 mm long; plants more than 2.5 dm tall, of Washington Co. .... *P. polyadenius* var. *polyadenius*

— Branches merely ascending, or rarely some divaricate; leaflets curved, at least some over 4 mm long; plants commonly less than 2.5 dm tall, of Emery Co. .... *P. polyadenius* var. *jonesii*

Var. *jonesii* Barneby. [*Dalea nummularia* M. E. Jones, type from Green River.] Salt desert shrub community, on Mancos Shale formation (Blue Gate Member) at ca. 1470 m in Emery Co.; endemic; 3 (0).

Var. *polyadenius*. [*Dalea polyadenia* Torr. ex S. Wats.; *Parosela polyadenia* (Torr.) Heller.] Creosote bush-Joshua tree community on pedimental gravels, Beaver Dam Mts., Washington Co.; Nevada and California; 2 (0).

Psorothamnus thompsonae **(Vail) Welsh & Atwood.** Thompson Indigo-bush. Armed shrubs, 2.5–8 dm tall or more; branchlets velvety with retrorse short hairs, conspicuously glandular with yellow- to orange-red mammiform resinous glands; stipules vestigial or to 0.8 mm long; leaves 0.7–5 cm long; leaflets 7–17, 1–10 mm long, 0.6–4 mm wide, linear to oblong, oval, or obcordate, glandular and strigose to glabrate beneath, strigose above, the uppermost jointed to the rachis; peduncles 0.4–1.8 cm long, rarely obsolete and some flowers axillary; racemes mainly 8- to 25-flowered, 2–9 cm long, the rachis retrorsely hairy; bracts 0.5–1.5 mm long, lanceolate, glabrous or hairy, soon deciduous; calyx 3.7–5 mm long, the tube 2.1–3.2 mm long, conspicuously 1-ribbed, glabrous or villous, ovate to oval, obtuse or only the lowermost acute; flowers 7.8–10.8 mm long, indigo or purple-pink; pods glandular-dotted. Two distinctive varieties occur in Utah.

1. Calyx tube villous; leaflets linear; plants of San Juan Co. .... *P. thompsonae* var. *whitingii*
— Calyx tube glabrous; leaflets oblong to oval or obcordate; plants of various distribution .... *P. thompsonae* var. *thompsonae*

Var. *thompsonae*. [*Parosela thompsonae* Vail]. Mixed desert shrub and salt desert shrub communities at 1170 to 2270 m in Garfield, Kane (?, the type supposedly from near Kanab, but more likely from Arizona), San Juan, and Wayne cos.; Arizona. There are no modern collections of this taxon from Kane Co.; 20 (iv).

Var. *whitingii* (Kearney & Peebles) Barneby. [*Dalea whitingii* Kearney & Peebles]. Mixed desert shrub community at 1230 to 1530 m in San Juan Co.; Arizona; 1 (0).

ROBINIA L.

Shrubs or trees, often armed; leaves alternate, odd-pinnate, the leaflets petiolulate and stipulate; stipules setaceous and caducous or persistent as spines; flowers in axillary racemes, white, pinkish, or pink, very showy, often aromatic; calyx campanulate to turbinate the 5 teeth triangular to triangular-acuminate; corolla papilionaceous; stamens 10, diadelphous; ovary subsessile or sessile; pods oblong, straight, laterally flattened, tardily dehiscent.

1. Uppermost pair of calyx teeth connate almost to the apex, forming an emarginate lip; branchlets and peduncles lacking hispid processes .... *R. pseudoacacia*
— Uppermost pair of calyx teeth free for about two-thirds of their length; branchlets and often the peduncles hispid 2

2(1). Branchlets and peduncles both glandular-hispid; shrubs, cultivated .... *R. hispida*
— Branchlets lacking processes; peduncles glandular-hispid; trees, cultivated or indigenous (in Washington Co.) .... *R. neomexicana*

***Robinia hispida* L.** Rose-Acacia. Shrubs, arising from root sprouts, spreading, commonly 1–2 m tall, except when grafted; branchlets both hispid and glandular-hispid; leaves 9.5–27 cm long; leaflets 7–13, 11–60 mm long, 7–40 mm wide, ovate or lance-ovate, elliptic, or oblong, obtuse, cuspidate, sparingly villous beneath, glabrous above; petioles hispid near the base; stipules obsolete; peduncles 1–4 cm long, hispid; racemes 3- to 10-flowered, 3–8 cm long; flowers 18–30 mm long, rose-pink; calyx turbinate-campanulate, the tube 4.5–6 mm long, the teeth 3.5–7 mm long, triangular-acuminate; pods hispid, seldom produced. Cultivated ornamental in Utah Co., and likely elsewhere; indigenous from Virginia and Kentucky to Georgia and Alabama. Evidence seems to indicate that rose-acacia is a sterile triploid, at least in part. Lack of fruit in plants from Utah seems to support this contention; 5 (ii).

***Robinia neomexicana* A. Gray.** New Mexico locust. [*R. neomexicana* var. *luxurians* Dieck.; *R. luxurians* (Dieck.) Schneid ex Taroua & Schneid; *R. breviloba* Rydb.; *R. subvelutina* Rydb.] Small trees or shrubs, mainly 1–8 m tall; branchlets villosulous, rarely glandular; leaves 8–20 (28) cm long; leaflets 9–19, 12–40 mm long, 7–20 mm wide, lance-oblong to oblong, obtuse, cuspidate, sparingly pubescent above and below, finally glabrate on one or both sides; petioles villosulous near the base; stipules 3–10 mm long or more, often spiny; peduncles 1–4 cm long, glandular-pubescent to hispid throughout; racemes 3- to 14-flowered, 3–8 cm long; flowers 16–24 mm long, pink; calyx campanulate, the tube 5–8 mm long, the teeth 3–5 mm long, triangular-acuminate pods 40–80 mm long, glandular-pubescent to hispid or glabrous. Talus slopes and terraces in Zion Canyon, Zion National Park, Washington Co.; Colorado, Nevada, Arizona, New Mexico, Texas, and Mexico. The plant is also known from cultivation in Cache and Utah cos., and is probably present elsewhere. The pink-flowered tree locusts of our region are all more or less involved through hybridization with the New Mexico locust and the black locust; 4 (i).

Robinia pseudoacacia **L.** Black Locust. Trees to 25 m tall or more; branchlets puberulent to villosulous, lacking glands; leaves (6) 8.5–26 cm long; leaflets (5) 11–25, 11–60 mm long, 6–30 (38) mm wide, lance-oblong to oblong, obtuse to retuse or cuspidate, puberulent to glabrate on both sides; petioles villosulous to pilose near the base; stipules minute, or represented by spines; peduncles 1.4–4.3 cm long, puberulent to villosulous; racemes 11- to 27-flowered, 4–13 cm long; flowers 12–20 (23) mm long, white (fading cream), or pale pink; calyx broadly campanulate to turbinate, the tube 3.5–5.5 mm long, the teeth 1.5–2 mm long, the upper pair connate, the sinus shallow; pods 40–120 mm long, glabrous. Cultivated ornamental, street, and shade trees, long-persisting and escaping; now known from Carbon, Cache, Grand, Kane, Millard, Salt Lake, Sanpete, Utah, Washington, and Wayne cos., and likely more widely cultivated; indigenous in the eastern United States. This is a handsome shade tree, with very hard wood. The flowers yield nectar, and the wood has been used for fence posts; 34 (x).

SOPHORA L.

Trees or herbs, unarmed; leaves alternate, odd-pinnately compound; stipules obsolete or herbaceous; flowers in terminal racemes or panicles, perfect, papilionaceous; calyx 5-toothed; petals all distinct; stamens 10, distinct or essentially so; ovary stipitate; pods spreading to pendulous, subterete, constricted between the seeds, indehiscent or tardily so.

1. Plants trees, cultivated; flowers borne in panicles in midsummer .... *S. japonica*

— Plants herbaceous, indigenous; flowers in racemes, opening in spring 2

2(1). Flowers blue-purple to blue; leaflets more than 5 times longer than broad, silvery-hairy .... *S. stenophylla*

— Flowers white to cream; leaflets less than 5 times longer than broad, gray-green .... *S. nuttalliana*

Sophora japonica **L.** Japanese Pagoda-tree. Trees to 12 m tall, the bark green and smooth for some years; branchlets sparingly villosulous to glabrate, leaf bases expanded, obscuring the axillary buds; leaves 12–23 cm long; leaflets 7–17, 14–60 mm long, 8–29 mm wide, lance-oblong to lanceolate, acute and apiculate, strigose beneath, glabrate or glabrous above; stipules obsolete; panicles many-flowered, 15–40 cm long; flowers 11–14 mm long, white to cream; calyx broadly campanulate 5.5–6.5 mm long, the tube 4.5–5.1 mm long, the teeth 0.8–1.2 mm long, broadly triangular; pods mainly 50–100 mm long, fleshy, constricted between the seeds. Cultivated ornamental, widely planted, but our records only from Salt Lake and Utah cos.; introduced from China; 5 (i).

Sophora nuttalliana **Turner.** Silky Sophora. [*S. sericea* Nutt.] Perennial, caulescent, 12–27 (30) cm tall, from a rhizome; pubescence essentially basifixed; stems ascending to erect; stipules 1.5–4 mm long, distinct, caducous; leaves 2.5–6 (7) cm long; leaflets 13–23, 2–11 mm long, 0.8–6 mm wide, oblong-obovate to obovate, rounded to retuse, often folded, strigose beneath, glabrous above; peduncles 0.8–3 cm long; racemes mainly 8- to 52-flowered, 3–9 cm long at anthesis, the axis 3–13 cm long in fruit; bracts 3–7 mm long; pedicels 2–4 mm long; bracteoles 1; calyx 8–10.5 mm long, gibbous, the tube 6.4–8.5 mm long, obliquely short-cylindric, the teeth 2–2.5 mm long, triangular; flowers 14–19 mm long, white to cream (fading cream); pods erect-ascending, stipitate, the stipe 6–12 mm long, the body 12–40 mm long, 3–4.5 mm thick, constricted tightly between the usually 1–3 seeds, strigose. River bottoms and roadsides at 1070 to 1670 m in San Juan and Washington cos.; Wyoming and South Dakota, south to Arizona, New Mexico, and Texas; 2 (0).

Sophora stenophylla **A. Gray.** Silvery Sophora. Perennial, caulescent, 13–41 cm tall (above ground), from deeply seated rhizomes; pubescence basifixed; stems ascending to erect; stipules 3–12 mm long, distinct, caducous, or obsolete; leaves 1.7–5.6 cm long; leaflets 9–15, 7–27 mm long, 0.5–4 mm wide, linear to narrowly oblong, acute to attenuate, silvery pilosulous, the pubescence fading yellowish in time; peduncles 1.7–5 cm long; racemes mainly 12- to 39-flowered, 5–17 cm long at anthesis, 6–23.5 cm long in fruit; bracts 3–7 mm long; pedicels 1–8 mm long; bracteoles 0; calyx 6.5–10.8 mm long, gibbous, the tube 4.8–7.2 mm long, obliquely short-cylindric, the teeth 1.7–3.6 mm long, ovate-triangular; flowers 15–27 mm long, blue-purple to blue; pods spreading declined, stipitate, the stipe 8–16 mm long, the body 15–60 mm long, 6–8 mm wide, strongly constricted between the usually 1–5 seeds, strigose. Sand dunes and other sandy sites, mainly in mixed desert shrub communities, at 900 to 2270 m in Emery, Garfield (at Red Canyon, with ponderosa pine), Grand, San Juan, Uintah, Washington, and Wayne cos.; New Mexico and Arizona. This is one of the most beautiful of the legume species in Utah; 41 (vi).

SPARTIUM L.

Shrubs, unarmed; leaves alternate to subopposite, simple; stipules obsolete; flowers in terminal, erect racemes, papilionaceous, perfect; calyx 1-lipped, the 5 teeth marginal, all on the lower side of the calyx, the three central ones approximate, the lateral ones somewhat removed; petals yellow, the keel pubescent along the lower edge, and with a porrect beak; stamens 10, monadelphous; ovary sessile; pods spreading-ascending, laterally compressed, many-seeded.

Spartium junceum **L.** Spanish Broom. [*Genista juncea* (L.) Lam.] Shrubs, 15–25 dm tall; leaves simple, 8–27 mm long, 0.5–4 mm wide, linear to narrowly oblanceolate, acute to obtuse, strigose on both sides; peduncles 3–22 cm long (from last leaf to first flower); racemes 3- to 16-flowered, 3–16 cm long; bracts minute, caducous; bracteoles 0; pedicels 1–4 mm long; calyx oblique, 7–8 mm long, glabrous, the teeth minute; flowers 21–26 mm long, yellow; pods sessile, 50–80 mm long, 5–7 mm wide, strigose, dihiscent. Cultivated ornamental in Washington Co.; widely cultivated in the South; introduced from southern Europe; 1 (i).

SPHAEROPHYSA DC.

Perennial, caulescent, from rhizomes; leaves alternate, odd-pinate; stipules adnate to the petiole base, all distinct; flowers papilionaceous, borne in axillary racemes, each subtended by a single bract; bracteoles 1; calyx 5-toothed; petals 5, dull red, drying lavender to brown; stamens 10, diadelphous; ovary enfolded by the staminal sheath; style glabrous except for a tuft of hair below the stigma; pods stipitate, bladdery-inflated, subunilocular.

Sphaerophysa salsula **(Pallas) DC.** [*Phaca salsula* Pallas; *Swainsona salsula* (Pallas) Taub. in Engl. & Prantl.] Perennial, caulescent, 40–70 cm tall, from a deeply placed rhizome; pubescence basifixed; stipules 1–4 mm long, all distinct; leaves 3–10 cm long; leaflets 15–25, 3–18 mm long, 1–7 mm wide, oblong-obovate to elliptic, retuse to obtuse and apiculate, strigose beneath, glabrous above; peduncels 2.5–9 cm long; racemes 5- to 17-flowered, the flowers ascending in anthesis, finally nodding, the axis 2.5–9 cm long in fruit; bracts 1–2 mm long; pedicels 2.5–8 mm long; bracteoles 2; calyx 5–6 mm long, the tube 3.8–4.6 mm long, campanulate, the teeth 1.2–2 mm long, triangular; flowers 12–14 mm long, dull-red, fading lavender to brown; pods ascending to declined, stipitate, the stipe 4–7 mm long, the body bladdery-inflated, ovoid, 13–24 mm long, 9–20 mm wide (when pressed), unilocular, strigulose. Introduced weedy species known from the Uinta Basin and to be expected anywhere; widespread in the western United States; adventive from Asia. This plant resembles an *Astragalus* species, and has been mistaken twice as belonging to previously undescribed and unnamed indigenous species (*A. violaceus* St. John; *A. iochrous* Barneby). Generic concepts revolving around this genus are unresolved and it seems likely that the plants will ultimately be placed with some earlier named genus; 1 (0).

Thermopsis R. Br.

Perennial herbs, caulescent, from rhizomes; leaves alternate, palmately trifoliolate; stipules foliaceous; flowers papilionaceous, borne in terminal racemes; bracts herbaceous, persistent; calyx 5-toothed; petals 5, yellow or suffused with purple, the keel rounded; stamens 10, distinct; ovary stipitate, the style glabrous; pods narrowly oblong, flattened, many-seeded.

1. Pods straight not especially loment-like, erect or ascending; plants mostly 20–70 cm tall or more, common through most of Utah .... *L. montana*

— Pods curved, loment-like, spreading to recurved; plants mostly 14–40 cm tall, known from Uintah Co. .... *L. rhombifolia*

***Thermopsis montana* Nutt. in T. & G.** Golden Pea, Yellow Pea. Caulescent, 20–75 (100) cm tall, the stems erect, pilosulous to glabrate; stipules foliar, lanceolate to ovate; 13–60 mm long, 3–30 mm wide; petioles 0.8–3.7 cm long; leaflets 3, 21–92 mm long, 5–36 mm wide, elliptic to lanceolate or oblanceolate, acute to rounded, pilosulous beneath, glabrous to glabrate above; peduncles 2.2–13 cm long; bracts 5–11 mm long; racemes mainly 2- to 23-flowered, 6–25 cm long in anthesis, the axis 9–28 cm long in fruit; flowers 20–26 mm long, yellow; calyx 10.2–12.3 mm long, the tube 7–8.3 mm long, obliquely campanulate, the teeth 3.1–4 mm long, ovate-triangular; pods erect or ascending, stipitate, the stipe 2.5–6 mm long, the body 40–54 mm long, 5–7 mm wide, pilose, stramineus or turning black. Moist sites along streams, in meadows, around seeps and springs at 1251 to 3416 feet in Box Elder, Daggett, Duchesne, Garfield, Juab, Kane, Millard, Morgan, Piute, San Juan, Sanpete, Sevier, Summit, Uintah, Utah, Wasatch, Washington, Wayne, and Weber cos.; British Columbia east to Montana and south to California, Arizona, and New Mexico. The abundant materials present in Utah herbaria demonstrate a wide range of variation in leaflet and stipule size and shape. There appears to be no basis for segregation of subordinate taxa, even those from the southern tier of counties known previously as *T. pinetorum* Greene or as *T. ovata* (Robins.) Rydb. [*T. montana* ssp. *ovata* Robins. ex Piper; *T. montana* var. *ovata* (Robins.) St. John]. The leaves of plants from Washington Co. average larger, but that is hardly a basis for segregation; 106 (xv).

***Thermopsis rhombifolia* Nutt. ex Richards.** Caulescent, 15–40 cm tall, the stems erect, glabrate; stipules foliose, ovate to oblanceolate, 6–30 mm long, 2–22 mm wide; petioles 0.3–2.5 cm long; leaflets 3, 15–47 mm long, 7–25 mm wide, obovate to oblanceolate, obtuse to rounded, glabrous beneath and above; peduncles 0.5–5.8 cm long; bracts simple to foliose; racemes mainly 4- to 30-flowered, 2–10 cm long in anthesis, the axis 2–12 cm long in fruit; flowers 18–22 mm long; calyx 7.5–10 mm long, the tube 4.5–4 mm long, triangular-ovate; pods divaricate, finally recurved, loment-like, stipitate, the stipe 1.5–4 mm long, the body 25–70 mm long, 5–7 mm wide, pilose to glabrate. Sandy and clay soils, mainly where moist, at 1500 to 1800 m in Daggett (Neese 4532 BRY) and Uintah Co. (Welsh 158; Cronquist 11499 BRY); Alberta and Saskatchewan south to Colorado and Nebraska.

Trifolium L.

Perennial or short-lived perennial or annual, caulescent or acaulescent, from a taproot and caudex or rhizome; leaves alternate, palmately to pinnately 3-foliolate, or rarely 4- to 7-foliolate, commonly serrate throughout, rarely entire; stipules membraneous to foliaceous, often connate; flowers papilionaceous, borne in terminal or axillary, pedunculate to sessile, subcapitate heads or racemes; calyx 5-toothed; petals 5, pink, white, or red-purple, withering and persistent, finally investing the pod; stamens 10, diadelphous; pods usually shorter than the calyx, indehiscent, 1- to several-seeded.

REFERENCES

GILLETT, J. M. 1965. Taxonomy of *Trifolium*: Five American species of Section Lupinaster (Leguminosae). Brittonia 17:107–112.

______. 1969. Taxonomy of *Trifolium* (Leguminosae). II. The *T. longipes* complex in North America. Canad. Jour. Bot. 47: 93–113.

______. 1971. Taxonomy of *Trifolium* (Leguminosae). III. *T. eriocephalum*. Canad. Jour. Bot. 49:395–405.

______. 1972. Taxonomy of *Trifolium* (Leguminosae). IV. The American species of section Lupinaster (Adanson) Seringe. Canad. Jour. Bot. 50:1975–2007.

MCDERMOTT, L. F. 1910. An illustrated key to the North American species of *Trifolium*. San Francisco. 325 pp.

1. Plants acaulescent or subacaulescent, mainly 1.5–10 cm tall 2

— Plants caulescent, with 1 or more elongated internodes (see also *T. parryi*); mainly 10–60 cm tall 7

2(1). Heads 1- to 4-flowered, essentially sessile, the flowers 15–23 mm long; plants of high elevations in Uinta and LaSal mountains .... *T. nanum*

— Heads several-flowered, sessile or pedunculate, the flowers either shorter or heads pedunculate; plants of various distribution 3

3(2). Plants densely pulvinate-caespitose, matted 4

— Plants loosely caespitose, not especially mat-forming 5

4(3). Calyces densely woolly-villous; herbage silvery-hairy; plants known from San Francisco Mts., Beaver Co. .... *T. andersonii*

— Calyces strigose to strigulous; herbage green, merely strigose; plants of Daggett, Summit, and San Juan cos. .... *T. andinum*

5(3). Leaflets toothed; calyces villosulous to pilosulous; flowers less than 9 mm long; plants of moderate elevation, broadly distributed .... *T. gymnocarpon*

— Leaflets entire, or if toothed then the calyces glabrous; flowers more than 9 mm long; plants of high elevations 6

6(5). Leaflets entire; calyces strigose; plants of the Uinta, LaSal, Abajo, and Henry mountains .... *T. dasyphyllum*

— Leaflets toothed; calyces glabrous; plants of the Uinta, LaSal, and Abajo mountains .... *T. parryi*

7(1). Plants stoloniferous, prostrate and rooting at the nodes; flowers white; calyx not bladdery-inflated; introduced, widespread .... *T. repens*

— Plants not stoloniferous (except in *T. fragiferum*), usually erect or ascending, not rooting at the nodes; flowers mainly pink to red-purple 8

8(7). Calyx soon bladdery-inflated and enclosing the corolla; plants introduced, uncommon .... *T. fragiferum*

— Calyx not accrescent or only slightly so, never enclosing the corolla; plants various 9

9(8). Heads sessile or nearly so, commonly immediately subtended by a trifoliolate bract; plants cultivated, escaping, and persisting .... *T. pratense*

— Heads with well-developed peduncles, not immediately subtended by foliose bracts; plants indigenous or cultivated 10

10(9). Peduncles bent at the apex, the heads reflexed or appearing turned to one side 11

— Peduncles straight, the heads erect 13

11(10). Calyx tube and teeth villous; ovary with hairs near the apex along the ventral side; plants of lower middle elevations in Juab, Sevier, and Beaver (?) cos. .... *T. eriocephalum*

— Calyx tube and teeth sparingly villosulous to glabrous; ovary glabrous, or scaly, but not hairy as above; plants of various distribution 12

12(11). Heads definitely longer than broad; calyx teeth shorter than the tube; basal leaves prominent, long-petioled; plants of Washington and Iron cos. .... *T. macilentum*

— Heads about as broad as long; calyx teeth subequal to the tube; basal leaves more shortly petioled than the subbasal ones; plants of Beaver, Emery, Garfield, Grand, Piute, San Juan, Sanpete, Sevier, Summit, and Utah cos. .... *T. kingii*

13(10). Heads subtended by a spinose-toothed involucre 14

— Heads lacking an involucre; plants from a caudex, variously distributed, common or uncommon 15

14(13). Plants annual; head 5–20 mm wide; plants of Salt Lake, Weber, and Cache cos. .... *T. variegatum*

— Plants perennial; head 20–30 mm wide; of Tooele and Salt Lake cos. .... *T. wormskjoldii*

15(17). Flowers mainly 7–9 mm long; heads axillary, from the uppermost nodes; plants cultivated, escaping, and persisting .... *T. hybridum*

— Flowers 10–16 mm long; heads terminal, solitary; plants indigenous 16

16(15). Calyx glabrous; flowers mainly 14–16 mm long; plants rare in Sevier Co. .... *T. beckwithii*

— Calyx villosulous to pilosulous; flowers mainly 10–12 mm long; plants widespread in Utah .... *T. longipes*

Trifolium andersonii **A. Gray.** Anderson Clover. Acaulescent, densely pulvinate-caespitose, mat-forming, 0.8–3 cm tall, from woody caudex branches and a thick taproot, the stems obscured by imbricated stipules and persistent leaf bases; petioles 0.3–1.1 cm long; leaflets 3–3.8 mm long, 1.5–3.4 mm wide, oblanceolate to obovate, entire or toothed near the apex and the teeth more or less obscured by pubescence, villosulous on both sides with hairs 0.3–0.7 mm long, commonly folded, mucronate; stipules scarious, pilose, 5–9 mm long; heads lacking an involucre, borne subsessile or on peduncles 0.2–0.6 cm long, these densely pilose; flowers 4–9, the banner reddish-purple, the keel and wings pale, 8–9 mm long, on pedicels ca. 0.5 mm long (obscured by pilose hairs); calyx 8.5–9.5 mm long, the tube 3–4 mm long, campanulate, obscured by villous hairs to 1.5 mm long, the teeth 5–7 mm long, subulate, villous; pods unknown (in our material). Volcanic gravels in pinyon-juniper woodland at 2130 m in San Francisco Mts., Beaver Co.; California and Nevada. Our plant differs in several salient features from *T. andersonii* sens. lat. It is therefore described as var. ***friscanum*** Welsh var. nov. Similis *Trifoliae andersonii* a qua imprimis differt pedunculis brevioribus, floribus parvioribus, et folium pili brevioribus. Holotype: Utah, Beaver Co., Grampian Hill, San Francisco Mts., Peabody, Taylor, & Thorne 406, 3 June 1976 (BRY); 3 (0).

Trifolium andinum **Nutt. in Torr & Gray.** Andean Clover. Acaulescent, densely pulvinate-caespitose, mat-forming, 0.3–5 cm tall, from woody caudex branches and a thick taproot, the stems obscured by imbricated stipules and persistent leaf bases; petioles 0–2.3 cm long; leaflets, 3, 2–12.5 mm long, 1.2–5 m wide, oblanceolate to obovate, toothed in the apical third, strigose to strigulose on both sides, commonly folded, abruptly acuminate; stipules scarious, yellowish, glabrous except towards the tip, 3–9 mm bng; heads closely subtended by reduced leaf-like bracts, these with or without a trifoliolate bract, sessile or appearing pedunculate by elongation of internodes on floriferous branches, the internodes glabrous; flowers 7–15, in two closely associated heads, the banner violet-purple, the keel and wings ochroleucous, 9–12 mm long, on pedicels 0.5–1 mm long, these glabrous to strigose; calyx 5–7 (8.5) mm long, the tube 2.2–3.6 (4) mm long, sparingly pilose to glabrous, the teeth 2–3.8 (4.5) mm long, lance-subulate, pilose; pods 4–5 mm long, 2.3–2.7 mm wide. Ponderosa pine, sagebrush, or mixed shrub communities at 1970 to 2730 m in Daggett, Summit, and San Juan cos.; Wyoming and Arizona. The existence of Andean Clover in two centers in Utah (i.e., on the north slope of the Uintas and on Navajo Mountain) is without precedence among the legumes of Utah. The plants from Navajo Mountain differ in features of the flower, mainly in the length of the calyx teeth and tube. Those from the Uinta Mountain centrum have calyx teeth subequal to or surpassing the tube; those from Navajo Mountain have calyx teeth much shorter than the tube; 6 (i).

Trifolium beckwithii **Brewer ex S. Wats.** Beckwith Clover. Caulescent, 12–40 cm tall, from rhizomes and thick roots; petioles of lower leaves 4–15 cm long, becoming shorter upwards; leaflets 3, 12–45 (50) mm long, 7–20 mm wide, elliptic to lance-elliptic or oblong, toothed from near the base, glabrous, flat, emarginate to apiculate; stipules prominent, herbaceous to scarious, 12–28 mm long; heads not subtended by an involucre, about as broad as long, 25–35 mm wide, terminal or axillary, on peduncles 5–26 cm long, these glabrous; flowers numerous, the petals pink, fading brown, 12–16.5 mm long; calyx 6.5–8 mm long, the tube 2.5–3.1 mm long, gibbous, glabrous, 5-veined, the teeth 3.5–4.9 mm long, lance-subulate, glabrous; pods 4.8–5.2 mm long, 1.9–2.1 mm wide. Meadows at 2070 to 2200 m in Sevier and Piute (?) cos.; California, Oregon, Nevada, Idaho, Montana, and South Dakota. Our collections from Utah have flowers and parts which average larger than for the species as a whole. The one locality for the species in Utah is common to *T. eriocephalum*; 2 (i).

Trifolium dasyphyllum **Torr. & Gray.** Uinta Clover. Acaulescent, loosely mat-forming, 2–14 cm tall, from a caudex and thick taproot, the stems obscured by imbricated stipules and leaf bases; petioles 0.3–4 cm long; leaflets 3, 3–28 mm long, 1–5 mm wide, oblanceolate, entire, strigose beneath, strigose to glabrate above, flat or folded, sharply apiculate; stipules scarious, glabrous or strigose, 5–17 mm long; heads closely subtended by a long-lobed involucre, 11–18 mm wide, terminal, sessile or on peduncles 0.5–10 cm long, these strigose; flowers 6–16, erect, the banner violet to ochroleucous, the keel and wings purple, or all purple, 11–13 mm long; pedicels 0.5–1.5 mm long; calyx 4.7–9.1 mm long, the tube 2.5–2.9 mm long, strigose to glabrate, the teeth 1.9–6.4 mm long, subulate, strigose to glabrate; pods 4–6 mm long. Alpine meadows at 2730 to 3800 m in Daggett, Garfield, Grand, San Juan, Summit, and Uintah cos.; Montana, Wyoming, Colorado, and New Mexico. Plants from Utah are assignable to var. **uintense** (Rydb.) Welsh stat. nov. based on *T. uintense* Rydb., Bull. Torrey Bot. Club 34: 47. 1907, type from Uinta Mts. [*T. dasyphyllum* f. *uintense* (Rydb.) McDermott; *T. dasyphyllum* ssp. *uintense* (Rydb.) J. M. Gillett]; 117; (0).

Trifolium eriocephalum **Nutt. in Torr. & Gray.** Woolly Clover. Caulescent, 12–36 (42) cm tall, from a caudex and tuberous to slender taproot; petioles 0.8–10 cm long; leaflets 3, 5–53 mm long, 5–12 mm wide, oblong to oblong-lanceolate or elliptic, toothed from near the base, thinly pilose to pilosulous on both sides, flat, obtuse to acute, apiculate; stipules foliaceous, glabrous or pilosulous, 15–55 mm long; heads lacking an involucre, 20–30 mm long, 20–27 mm wide, terminal, on peduncles 4–11 cm long, bent apically, thinly villosulous; flowers numerous, curved at base and reflexed, the petals purple to red-purple, rarely white, fading brown, 12–13.5 mm long; pedicels essentially obsolete; calyx 6.5–8 mm long, the tube 2.5–3.3 mm long, villosulous, the teeth 3.5–5.1 mm long, villosulous to glabrate, subulate; pods 2.5–7 mm long. Meadows at 1530 to 2270 m in Beaver (?), Juab, and Sevier cos.; Washington, Idaho, Montana, California, and Nevada. Our few specimens are assignable to var. ***villiferum*** **(House) Martin** [*T. villiferum* House; *T. eriocephalum* f. *villiferum* (House) McDermott; *T. eriocephalum* ssp. *villiferum* (House) J. M. Gillett]. The type (US) of *T. villiferum* is labeled as "S. Utah. Dr. E. Palmer 91, 1877." Gillett (1971) cites the type locality as "Beaver City, Beaver Co., Utah." The problem of type locality is the same as that for *Psoralea mephitica* (q.v.) and *P. castorea*, both cited as being from "near Beaver City, S. Utah." That neither came from there was alluded to by Palmer (see citation under *P. mephitica*), and also by Jones (Cal. Acad. Sci. II. 5:632. 1895) who noted that "Dr. Palmer never collected any plants at Beaver City, Utah, during the year in which he collected these species *P. mephitica* and *P. castorea*, but he did collect in that year in the Beaverdam Mountains on the northeastern corner of Arizona at a place called Beaverdam [sic]. Thus, the type locality of *T. villiferum* is in doubt, but it seems likely that the specimens came from Washington Co., where it is unknown from recent collections; 8 (ii).

Trifolium fragiferum **L.** Strawberry-headed Clover. Caulescent, 5–30 cm long, rhizomatous and sometimes stoloniferous, decumbent to ascending; petioles 0.5–13 cm long; leaflets 3, 6–22 mm long, 4–15 mm wide, obovate, toothed from near the base, truncate to retuse and apiculate, flat, glabrous to glabrate on both sides; stipules scarious, 8–20 mm long; heads involucrate, many-flowered, subglobose, 10–22 mm wide, on peduncles 2–17 cm long, these glabrous; flowers 4–6 mm long, purplish, finally included within the accrescent calyx; calyx finally bladdery-inflated, pilose, reticulately veined around translucent lacunae. Meadows, roadsides, and other disturbed sites at 1370 to 2135 m in Cache, Garfield, Juab, Millard, Summit, Piute, Salt Lake, Utah, and Weber cos., and likely elsewhere; introduced from Europe; 10 (ii).

Trifolium gymnocarpon **Nutt. in Torr. & Gray.** Nuttall Clover. Acaulescent to short-caulescent, 4–16 cm tall, from a caudex and taproot, the stems mainly obscured by imbricated stipules and leaf bases; petioles 1–9 cm long; leaflets 3–5, 6–23 mm long, 2–10 mm wide, elliptic to oblong, ovate, or obovate, toothed from near the base, pilosulous beneath, glabrous to pilosulous above, flat or folded, rounded to acute and apiculate; stipules scarious to herbaceous, 6–23 mm long; heads without an involucre, hemispheric, commonly 12–18 mm wide, terminal and axillary, on peduncles 1–6.5 cm long, these strigulose, erect to bent apically; flowers 6–15, the lower ones reflexed in age, the petals pink to lavender or purple, 8.5–11 mm long; pedicels 0.5–1 mm long; calyx 4.4–7 mm long, the tube 2.2–3.3 mm long, strigose, the teeth 1.8–3.7 mm long, subulate, strigose; pods 4–8 mm long, 3–4.5 mm wide. Two weak, sympatric varieties occur in Utah. They are hardly worth taxonomic recognition, but possibly represent trends.

1. Leaflets glabrous above .... *T. gymnocarpon* var. *gymnocarpon*
– Leaflets pilose above .... *T. gymnocarpon* var. *plummerae*

Var. *gymnocarpon*. [*T. subcaulescens* A. Gray in Ives; *T. gymnocarpon* var. *subcaulescens* (A. Gray) A. Nels.; *T. nemorale* Greene]. Mixed desert shrub, pinyon-juniper, mountain brush, sagebrush, ponderosa pine, Douglas fir, and spruce-fir communities at 1570 to 2900 m in Carbon, Daggett, Duchesne, Garfield, Juab, Kane, Millard, Piute, San Juan, Sanpete, Sevier, Uintah, Utah, and Wayne cos.; Nevada, Wyoming, Colorado, Arizona, and New Mexico; 25 (x).

Var. *plummerae* (S. Wats.) Martin. [*T. plummerae* S. Wats.; *T. gymnocarpon* f. *plummerae* (S. Wats.) McDermott; *T. gymnocarpon* ssp. *plummerae* (S. Wats.) Gillett]. Sagebrush, pinyon-juniper, and other communities at 1530 to 2430 m in Beaver, Carbon, Daggett, Duchesne, Millard, San Juan, Sanpete, Summit, Uintah, Wasatch, and Wayne cos.; Oregon, Idaho, Wyoming, California, and Nevada. This phase intergrades completely with the preceding in Utah, and if recognized at any taxonomic level, should best be treated at the rank of forma, as was done by McDermott; 10 (0).

***Trifolium hybridum* L.** Alsike Clover. Caulescent, 15–70 cm tall, erect or ascending (rarely decumbent), from a caudex and taproot; petioles 0–16 cm long; leaflets 3, 5–38 mm long, 3–28 mm wide, oval to lance-elliptic, ovate or obovate, flat, toothed from near the base, glabrous on both sides, obtuse to retuse and apiculate; stipules herbaceous, 5–25 mm long; heads without an involucre, 12–25 mm wide, terminal and axillary on peduncles 1.5–13 cm long, these glabrous or glabrate, erect; flowers many, the lower reflexed in age, the petals white to pink or reddish, fading red-brown, 5–9 mm long; calyx 2.7–4 mm long, the tube 1.2–1.6 mm long, glabrous, scarious, the teeth 1–2.5 mm long, subulate, glabrous; pods 1- to 3-seeded. Cultivated, short-lived, forage plant, escaping and persisting (?) in Cache, Davis, Garfield, Piute, Salt Lake, San Juan, Sanpete, Summit, Utah, Wasatch, and Weber cos.; and perhaps universal; introduced from Europe; 21 (ii).

***Trifolium kingii* S. Wats.** King Clover. Caulescent, (2) 7–40 cm tall, erect or ascending, from a caudex and taproot; petioles 0.8–15 cm long, the longest near the base but not basal; leaflets 3, 5–80 mm long, 4–26 mm wide, elliptic to lance-elliptic or lanceolate, flat, toothed from near the base, glabrous on both sides, obtuse to acute or attenuate and apiculate; stipules foliaceous, 8–30 mm long; heads nodding to suberect, without an involucre, 15–32 mm long, 15–30 mm wide (when pressed), terminal, on peduncles 3–13 cm long, these glabrous; flowers many, reflexed, the petals violet to purplish (rarely white), 12–16 mm long; calyx 5.3–9 mm long, glabrous, the tube 2.1–3.5 mm long, the teeth 1.8–6 mm long, subulate; pods 1- to 3-seeded. Meadows and open woods at 2270 to 3700 m in Beaver, Emery, Garfield, Grand, Piute, San Juan, Sanpete, Sevier, Summit, and Utah cos.; endemic. With its nodding heads and reflexed flowers, the King clover simulates *T. eriocephalum* in all salient aspects. The main differential feature involves the pubescence of herbage and calyces in *T. eriocephalum*; 35 (v).

***Trifolium longipes* Nutt. in Torr. & Gray.** Rydberg Clover. Caulescent (rarely acaulescent), 5–31 (37) cm tall, erect or ascending from a branching caudex and stout to slender taproot; petioles 1.2–10 cm long; leaflets 3, 5–47 (57) mm long, 3–18 mm wide, narrowly oblong to elliptic, oblanceolate, or obovate, flat, toothed from near the base, pilosulous beneath, glabrous above, acute to obtuse and apiculate; stipules foliaceous, 8–40 mm long; heads erect, without an involucre, 17–31 mm long, 15–33 mm wide (when pressed), terminal, on peduncles 0.5–17 cm long, these strigulose; flowers many, finally reflexed, the petals whitish to pink or purple, 11–13 mm long; calyx 4.5–7.8 mm long, the tube 1.6–2.5 mm long, scarious, pilose distally, the teeth 2.9–5.8 mm long, pilose, subulate; pods 1-to 4-seeded. This is the common clover in mountains in Utah. There are two rather distinctive and largely allopatric varieties.

1. Leaflets of main leaves commonly more than 5 times longer than broad; roots slender, not much enlarged; plants of the Uinta, Deep Creek, LaSal, and Abajo mountains .... *T. longipes* var. *reflexum*

— Leaflets of main leaves commonly less than 4 times longer than broad; roots tuberous-thickened; plants mainly of southwestern Utah (also in San Juan Co.) .... *T. longipes* var. *pygmaeum*

Var. *pygmaeum* A. Gray in Ives. [*T. longipes* ssp. *pygmaeum* (A. Gray) J. M. Gillett; *T. longipes* var. *brachypus* S. Wats., type from St. George; T. *brachypus* (S. Wats.) Blankinship; *T. rusbyi* Greene; *T. confusum* Rydb., type from southern Utah, i.e., Sheep Range, Cedar City; *T. oreganum* f. *rusbyi* (Greene) McDermott; *T. oreganum* f. *brachypus* (S. Wats.) McDermott; *T. longipes* var. *rysbyi* (Greene) Harrington]. Alpine meadows, open woods, stream banks, and grasslands at 1830 to 3500 m in Beaver, Emery, Garfield, Iron, Kane, Piute, San Juan, Sevier, and Washington cos.; Colorado, New Mexico, and Arizona; 47 (v).

Var. *reflexum* A. Nels. [*T. longipes* ssp. *reflexum* (A. Nels.) J. M. Gillett; *T. rydbergii* Greene; *T. oreganum* var. *rydbergii* (Greene) McDermott]. Meadows, stream banks, woods, and willow communities at 1870 to 3050 m in Cache, Daggett, Duchesne, Grand, Juab (Deep Creek Mts.), Salt Lake, San Juan, Summit, Uintah, Utah, and Wasatch cos.; Oregon, Idaho, Montana, Nevada, Wyoming, Colorado, and New Mexico; 30 (iv).

***Trifolium macilentum* Greene.** Lean Clover. [*T. kingii* ssp. *macilentum* (Greene) J. M. Gillett]. Caulescent, 12–35 cm tall, ascending to decumbent, from a caudex and taproot; petioles 2–16 cm long, the longest definitely basal; leaflets, 3, 14–45 mm long, 4–25 mm wide, those of basal leaves broadly ovoid to lance-ovoid, those of cauline leaves narrowly lanceolate, flat, toothed from near the base, glabrous on both sides, retuse to obtuse, acute to attenuate and apiculate; stipules dimorphic, the lower ones scarious and very long, the cauline ones herbaceous and small; heads nodding to suberect, without an involucre, 21–40 mm long, these glabrous; flowers many, reflexed, violet to purplish, 13.5–17 mm long; calyx 4–5.7 mm long, pilose, the tube 2.2–3 mm long, the teeth 1.5–3.3 mm long, subulate; pods 1- to 3-seeded. Mountain brush, pinyon-juniper, and ponderosa pine communities at 1370 to 2270 m in western Beaver (Ostler 1276 BRY), Iron, and Washington (type from S. Utah, Palmer 90 US) cos.; Lincoln Co. Nevada. The lean clover was subordinated by Gillett (1972) within *T. kingii*, on the basis of specimens from Nevada which were mistaken for typical *T. kingii*. The lean clover is a plant of dryish hillsides at lower elevations, differing further in its strongly dimorphic leaves, flowers which average larger, and pilose (though sparingly) calyces which average shorter. Thus, it differs from *T. kingii* in about the same order of magnitude as does *T. eriocephalum*; 12 (ii).

***Trifolium nanum* Torr.** Dwarf Clover. Acaulescent, pulvinate-caespitose, 2–4 cm tall, from a caudex and taproot, the stems obscured by imbricated stipules and leaf bases; petioles 0.3–2 mm long; leaflets 3, 3–11 mm long, 1–5 mm wide, oblanceolate to obovate, toothed to entire, glabrous or with some hairs on the lower surface, folded or flat, acute to mucronate; stipules scarious to herbaceous; heads 1- to 4-flowered, with an involucre of distinct to connate bracts, terminal, sessile or on peduncles 0.3–4 cm long, these glabrate to glabrous; flowers 15–23 mm long, pale purplish (fading dark violet), erect; pedicels 1–2 mm long; calyx 5–7 mm long, the tube 3.5–4 mm long, scarious, glabrous, the teeth 2.2–2.8 mm long, trianular-subulate, glabrous; pods 1- to 4-seeded. Alpine meadows at 2900 to 3730 m in Daggett, Grand, San Juan, Summit, and Uintah cos. (probable in Duchesne Co. also); Montana, Wyoming, Colorado, and New Mexico. The dwarf clover is one of our most distinctive, yet poorly collected, clovers. More work is necessary to elucidate its true range in Utah; 7 (0).

Trifolium parryi* A. Gray.** Parry Clover. Acaulescent, or short caulescent and with one elongate internode, 4–25 cm tall, from a caudex and taproot; petioles 0.6–13 cm long; leaflets 3, 5–43 mm long, 1.5–13 (16) mm wide, oblanceolate or obovate to elliptic or oblong, flat, toothed from near the base, glabrous on both sides, acute to obtuse and apiculate; stipules scarious to herbaceous, 6–18 mm long; heads 5- to 20-flowered, subtended by involucral bracts, terminal, on peduncles 1.8–22 cm long, these glabrous or sparingly hairy near the apex; flowers 12–17 mm long, the petals pale to dark pink-purple (fading dark violet), erect; pedicels 0–1 mm long; calyx 4–7.1 mm long, the tube 2–3.9 mm long, scarious, glabrous, the teeth 2–3.2 mm long, lance-subulate; pods 1- to 4-seeded. Alpine meadows, openings in spruce woods, and other coniferous woods, and on talus slopes at 2730 to 3800 m in Daggett, Duchesne, San Juan, Summit, Uintah, and Wasatch cos.; Montana, Wyoming, and Colorado. Our materials belong to var. ***montanense **(Rydb.) Welsh** stat. nov. based on *T. montanense* Rydb., Mem. N. Y. Bot. Gard. 1:263. 1900. [*T. parryi* ssp. *montanense* (Rydb.) J. M. Gillett; *T. inequale* Rydb., type from Bear River Canyon, Uinta Mts.]; 26 (iii).

Trifolium pratense **L.** Red Clover. Caulescent, short-lived perennial, 18–60 cm tall or more, from a taproot, erect or ascending; petioles 0.8–19 cm long; leaflets 3, 11–54 mm long, 8–28 mm wide, elliptic to lanceolate, ovate, or obovate, flat, toothed from near the base (the teeth inconspicuous), long-pilose beneath, glabrous above, obtuse to retuse; stipules scarious to subherbaceous, 10–24 mm long; head closely subtended by one or more foliose bracts, these often 3-foliolate, sessile, or spreading hairy peduncles to 3 cm long, many-flowered, 22–36 mm long, 20–34 mm wide, axillary, erect; flowers 13–20 mm long, deep red; calyx 7.5–9.7 mm long, the tube 3.2–4.1 mm long, strigose, scarious, the teeth 4.3–5.6 mm long, subulate, pilose; pods 2-seeded. Cultivated forage plant, escaping but seldom persisting, in Beaver, Box Elder, Daggett, Davis, Garfield, Kane, Millard, Salt Lake, Sevier, Summit, Utah, Wasatch, and Washington cos.; and perhaps universal; introduced from Europe; 26 (i).

Trifolium repens **L.** White Clover. Caulescent, 8–35 cm tall, the stems stoloniferous, creeping and rooting at the nodes, the petioles and peduncles often arising at right-angles to the stem axis, radiating from a root crown; petioles 1.8–24 cm long; leaflets 3, 5–22 mm long, 4–18 mm wide, obcordate or obovate to oval or elliptic, flat, toothed from near the base, glabrous on both sides, truncate to emarginate; stipules scarious, 3–10 mm long; heads without an involucre, many-flowered, 10–32 mm long, 15–30 mm wide, axillary, on peduncles 6–33 cm long, these glabrous or sparingly pilose, erect; flowers 5–9 (10) mm long, white or pinkish, fading brown, the lower reflexed in age; calyx 3.2–5.4 mm long, the tube 2.2–2.7 mm long, scarious, glabrous, the teeth 1–2.7 mm long, subulate, glabrous; pedicels 1–6.4 mm long; pods 1- to 3-seeded. Cultivated forage and pasture plant, now widely established in Beaver, Box Elder, Cache, Carbon, Garfield, Grand, Kane, Piute, Salt Lake, Sanpete, Sevier, Summit, Utah, Wasatch, and Washington cos. (perhaps cosmopolitan); introduced from Europe; 39 (iv).

Trifolium variegatum **Nutt. in T. & G.** Variegated Clover. Annual, caulescent, with prostrate to erect stems 10–40 (60) cm long; petiole 0.5–4.5 cm long; leaflets 3, 3–27 mm long, 1.5–10 mm wide, obcordate to obovate or oblanceolate, flat, sharply toothed from near the base, glabrous on both sides; stipules herbaceous, ovate, laciniately toothed; heads involucrate, the involucre flaring, saucer-shaped, lobed and lacerate, 3- to 40-flowered, 6–20 mm broad, axillary on peduncles 0.8–6.5 long, these glabrous; flowers 5–12 (20) mm long, purplish, often white-tipped, fading brown, ascending to erect; calyx 5- to 20-nerved, the teeth subulate-setaceous, glabrous; pedicels very short; pods 1- to 2-seeded. Stream banks and roadsides, at 1300 to 1600 m in Cache, Salt Lake, and Weber cos.; British Columbia and Montana south to California and Nevada. Our only annual clover species is not common in Utah.

Trifolium wormskjoldii **Lehm.** Wormskjold Clover. [*T. involucratum* Ortega, not Lam.; *T. willdenovii* Spreng.; *T. fimbriatum* Lindl.; *T. involucratum* var. *fimbriatum*

(Lindl.) McDermott; *T. willdenovii* var. *fimbriatum* (Lindl.) Ewan; *T. spinulosum* Douglas ex Hook.; *T. heterodon* Torr. & Gray.] Caulescent, 12–35 cm tall or more, from a taproot, or sometimes rooting at decumbent stem bases, erect or ascending; petioles 1.2–4 cm long; leaflets 3, 6–30 mm long, 2–14 mm wide, oblanceolate to elliptic or obovate, flat, toothed from near the base, glabrous throughout; stipules herbaceous, 8–15 mm long, man-toothed; heads subtended by a toothed involucre, 20–30 mm wide, many-flowered, axillary, erect; flowers 10–18 mm long, reddish to purple; calyx 7–9 mm long, the tube 2.9–3.7 mm long, glabrous, the teeth 4.1–5.3 mm long, subulate, glabrous; pods 1- to 4-seeded. Meadows at lower middle elevations in Juab and Salt Lake cos.; British Columbia and Idaho south to California, Mexico, and New Mexico. This plant is rare in collections, yet our earliest record, that for Salt Lake Co., was collected in 1880; 2 (0).

TRIGONELLA L.

Annual or short-lived perennial, caulescent from a taproot; leaves alternate, pinnately 3-foliate, serrate in the apical one-third to one-half; stipules herbaceous, distinct, toothed or entire; flowers papilionaceous, borne in axillary racemes or subumbellately disposed; calyx 5-toothed; petals 5, yellow; stamens 10, diadelphous; pods laterally compressed, much surpassing the calyx, several seeded.

Trigonella corniculata **(L.) L.** [*Trifolium* (*Melilotus*) *corniculata* L.]. Annual, caulescent, 12–26 cm tall; stipules 3–6 mm long, laciniately toothed; petioles 0.5–4.5 cm long; leaflets 3, the terminal on a short continuation of the rachis, 7–20 mm long, 2.5–16 mm wide obovate to obcordate, toothed in the apical half, sparingly pilose (mainly along veins) beneath, glabrous above, apiculate; peduncles 0.8–2.8 cm long, sparingly pilose; racemes 5- to 16-flowered, 0.8–1.4 cm long; pedicels 1–2 mm long; flowers 5.5–6.5 mm long, yellow; calyx 2.8–3.2 mm long, the tube 1.4–1.8 mm long, sparingly pilose, the teeth 1.2–1.4 mm long, subulate; pods sessile, 12–15 mm long, 2–2.5 mm wide, curved, reticulately veined, the veins leaving the margins at about right-angles, glabrous. Introduced revegetation plant, not known to persist, but to be expected, now known only from Sanpete Co.; introduced from Europe. A second species of *Trigonella* is known from Sanpete Co., also, but its identity has not been established. It differs from *T. corniculata* in its flowers being 10–12 mm long and subumbellately arranged. Further study is indicated; 2(0).

VICIA L.

Annual or perennial herbs, clambering, trailing, or climbing; leaves alternate, even-pinnately compound, the rachis terminating in a usually prehensile tendril; stipules herbaceous, entire to semi-sagittate; leaflets 4–12 or more, very variable; flowers solitary, axillary, or in axillary racemes, papilionaceous; calyx 5-toothed, obliquely campanulate to short-cylindric; petals 5, pink to white, the wings adnate to the keel; stamens 10, diadelphous; style filiform, bearded around the circumference below the stigma; pods oblong, 2- to several-seeded, the valves coiling upon dehiscence.

REFERENCE

HERMAN, F. J. 1960. Vetches of the United States—native, naturalized, and cultivated. U.S.D.A. Agr. Handb. 168: 1–84.

1. Flowers 15 or more in dense secund racemes; introduced plants of cultivated lands and other disturbed sites .... *V. villosa*

— Flowers 10 or fewer, in secund racemes or otherwise; introduced or indigenous plants 2

2(1). Flowers 5–8 mm long; plants very slender, indigenous in southern Utah .... *V. ludoviciana*

— Flowers 12–25 mm long or more; plants not very slender, indigenous and widespread or cultivated 3

3(2). Flowers 3–10 in pedunculate racemes; plants indigenous, widespread .... *V. americana*

— Flowers 1–3, sessile or very shortly pedunculate in leaf axils; plants uncommon, cultivated .... *V. faba*

Vicia americana **Muhl. ex Willd.** American Vetch. Perennial, 12–127 cm tall, the stems glabrous or pubescent; stipules 3–10 mm long, semi-sagittate, deeply toothed in the lower portion; leaves (excluding tendrils) 2–3 cm long; leaflets 8–16, 3–44 mm long, 1–19 mm wide, linear, elliptic, oblong, ovate, lanceolate, oblanceolate, or obovate, glabrous to pubescent, acute to truncate, rounded, or retuse and apiculate, less commonly toothed apically; tendrils branched or simple; peduncles 1.8–6.7 cm long; racemes 3- to 7 (10) -flowered, the flowers spreading in anthesis; calyx 6.2–8.4 mm long, the tube 4.8–6.5 mm long, the lowermost tooth 0.7–1.9 (2.5) mm long, triangular; flowers 13–22 (25) mm long, pink to pink-purple; pods stipitate, the stipe 2.5–4.5 mm long, the body 23–35 mm long, 6–8 mm wide, glabrous. This widespread, indigenous vetch is extremely variable with regard to leaflet length-width ratios and shape. Thickness of the leaflets and pubescence also varies considerably. Several subordinate taxa have been based on these variations, but continued recognition seems possible only when diagnostic criteria are arbitrarily applied, and even then with great difficulty, especially in plants with dimorphic leaves. More importantly, much of the variation seems to be ecologically influenced, and further recognition of most of the types seems unwarranted. Therefore, it seems best to recognize only two infraspecific taxa, the one widespread and common, the other restricted and rare.

1. Leaflets 20–40 mm long, 2–5 mm wide, coriaceous, pubescent with short curved hairs; lateral veins prominent, leaving the midrib at a narrow angle; plants of Uintah Co. .... *V. americana* var. *minor*

— Leaflets 3–44 mm long, 1–19 mm wide, thin or glabrous, or both; lateral veins prominent or not, leaving the midrib at a wide angle; plants throughout Utah .... *V. americana* var. *americana*

Var. *americana*. [*V. oregana* Nutt. in Torr. & Gray; *V. americana* var. *oregana* (Nutt.) A. Nels. in Coult. & Nels.; *V. americana* ssp. *oregana* (Nutt.) Abrams; *V. truncata* Nutt. in Torr. & Gray; *V. americana* var. *truncata* (Nutt.) Brew. in Brew. & Wats.] Sagebrush, pinyon-juniper, mountain brush, ponderosa pine, aspen, and spruce-fir communities at 1270 to 3050 m in Beaver, Carbon, Cache, Davis, Duchesne, Emery, Garfield, Iron, Juab, Kane, Millard, Morgan, Rich, Salt Lake, San Juan, Sanpete, Sevier, Summit, Tooele, Utah, Wasatch, Washington, and Weber cos.; British Columbia east to Ontario and south to Mexico, Arizona, New Mexico, Kansas, Missouri, and Virginia; 167 (xxxv).

Var. *minor* Hook. [*V. sylvatica* Nutt.; *V. sparsifolia* Nutt. in Torr. & Gray; *Lathyrus linearis* Nutt. in Torr. & Gray; *V. linearis* (Nutt.) Greene; *Lathyrus dissitifolius* Nutt. in Torr. & Gray; *V. dissitifolius* (Nutt.) Rydb.; *V. americana* var. *angustifolia* Nees in Wied.; *V. caespitosa* A. Nels.; *V. trifida* Dietr.] Pinyon-juniper and mixed desert shrub communities at 1670 to 1830 m in Uintah Co.; Alberta east to North Dakota and south to Colorado and Texas; 1 (0).

Vicia faba **L.** Broadbean. Annual, 40–100 cm tall or more, the stems glabrous; stipules 4–15 mm long, semi-sagittate, not or only somewhat toothed; leaves (excluding tendrils) 6–14 cm long; leaflets 2–6, 30–75 (100) mm long, 13–40 mm wide, ovate-lanceolate to elliptic or obovate, glabrous or with short curved hairs on veins and margin, obtuse to acute and apiculate; tendrils unbranched; peduncles very short or obsolete; racemes 1- to 4-flowered, the flowers erect-ascending; calyx 12–16 mm long, the short-cylindric tube 7.5–9.5 mm long, the lowermost tooth 3.5–6.5 mm long, lance-subulate; flowers 25–31 mm long, white, spotted with maroon or blackish-violet; pods subsessile to substipitate, the body 70–130 mm long or more, 10–30 mm wide, glabrous. Sparingly cultivated vegetable plant, mainly for the large edible seeds, known from Wasatch Co., but to be expected in most communities in the state; introduced from Asia; 1 (1).

Vicia ludoviciana **Nutt.** Louisiana Vetch. [*V. exigua* Nutt. in Torr. & Gray; *V. thurberi* S. Wats.; *V. producta* Rydb.] Annual or winter annual, 30–85 cm tall, the stems glabrous or puberulent; stipules semi-hastate to linear-oblong, 1–4 mm long; leaves (excluding tendrils) 1.8–5.5 cm long; leaflets 6–10, 7–28 mm long, 0.6–4 mm wide, linear to oblong or oblanceolate, pilosulous to glabrous, obtuse to acute and mucronate; tendrils branched and prehensile; peduncles 0.4–4.8 cm long; racemes 1 (2) -flowered, the flowers ascending to spreading at anthesis; calyx 2.2–3.3 mm long, the campanulate tube 1.4–1.9 mm long, the lowermost tooth 0.8–1.4 mm long, lance-subulate; flowers 6.3–7.4 mm long, lavender; pods stipitate, the stipe 0.8–1.4 mm long, the body 16–28 mm long, 5–6.2 mm wide, glabrous. Blackbrush, creosote bush, and pinyon-juniper communities at 900 to 1730 m in San Juan and Washington cos.; Oregon, California, Nevada, Arizona, New Mexico, Colorado, and Texas; 8 (i).

Vicia villosa **Roth.** Hairy Vetch. Annual or biennial, 50–200 cm tall, the stems spreading-hairy; stipules toothed or entire, 5–15 mm long; leaves (excluding tendrils) 2.3–8 cm long; leaflets 10–18, 8–30 mm long, 1–6 mm wide, linear to oblong or narrowly lanceolate, long-pilose or hirsute on both sides, acute to obtuse and apiculate; peduncles 1.8–7.5 cm long; racemes mainly 15- to 25-flowered, the flowers declined at anthesis; calyx 7–7.8 mm long, the gibbous tube 3.8–4.7 mm long, the teeth 3.1–4.3 mm long, subulate, pilose; flowers 15–17 mm long, pink-purple or reddish-violet; pods 20–30 mm long, 7–10 mm wide, glabrous. Weedy introduction of cultivated lands and other disturbed sites, often along fence-rows, in Salt Lake, Utah, Washington and Weber cos., but to be expected elsewhere; adventive from Europe; 5 (0).

WISTERIA Nutt.

Twining woody vines, unarmed; leaves alternate, odd-pinnate with 7 or more leaflets; stipules ovate to lance-linear, caducous; peduncles opposite the leaves; flowers in elongate, pendulous racemes, calyx turbinate-campanulate, 2-lipped, the upper lip shortly 2-toothed, the lower 3-toothed; corolla papilionaceous, the banner strongly reflexed; stamens 10, diadelphous; petals white, pink, lavender, purple, or blue; pods stipitate, laterally flattened, constricted between the seeds.

1. Longest pedicels 12–28 mm long or more; calyx lobes very short; pods silky- to velvety-hairy .... *W. floribunda*

— Longest pedicels 6–11 mm long; calyx lobes almost as long as the tube; pods glabrous .... *W. macrostachya*

Wisteria floribunda **(Willd.) DC.** Japanese Wisteria. [*Glycine floribunda* Willd.; *Kraunia floribunda* (Willd.) Taub.; *W. macrobotrys* Sieb. & Zucc.] Twining vines to several meters long; leaves petiolate, 9–35 cm long; leaflets 9–15, 13–90 mm long, 9–30 mm wide, ovate to lance-oblong, long-attenuate, pilose to glabrate or glabrous on both sides; peduncles 0.5–5 cm long; racemes pendulous, many-flowered, 25–50 cm long; flowers 15–20 mm long, white, pink, purple, or lavender; calyx tube strigulose, 3.5–4.3 mm long, the upper teeth almost completely connate, the lowermost tooth 1.3–2.1 mm long, triangular; pods 100–180 mm long, 15–18 mm wide, tapering to the base, velvety hairy in lines. Cultivated ornamental of great beauty in both grafted and free growing forms in Utah Co., and likely in most low elevation population centers in the state; introduced from Japan; 3 (ii).

***Wisteria macrostachya* Nutt.** Nuttall Wisteria. Freely twining vines to several meters long; leaves 15–40 cm long; leaflets 9–13, 28–90 mm long, 9–33 mm wide, ovate to lance-oblong, long-acuminate, pilose along the veins beneath at maturity, pilose to glabrate or glabrous otherwise; peduncles 1–5 cm long; racemes pendulous, many-flowered, 22–55 cm long; flowers 18–22 mm long, lilac-purple; calyx tube pilosulous, 4.5–5.5 mm long, the upper teeth cleft, the lowermost tooth 5.5–6.5 mm long, ovate-acuminate; pods 70–120 mm long, 11–15 mm wide, oblong, glabrous. Ornamental of charm and beauty in Utah Co., and likely elsewhere in Utah; introduced from the southeastern United States; 3 (iii).

Index of Names and Synonyms

- Acacia 231
  - greggii 231
- Albizia 231
  - julibrissin 231
- Amorpha 231
  - canescens 232
  - fruticosa 232
- *Anisolotus*
  - *longebracteatus* 320
  - *numularius* 320
  - *rigidus* 320
  - *wrightii* 321
- Anthyllis 232
  - vulneraria 232
- Arachis 232
  - hypogaea 232
- *Aragallus*
  - *besseyi* 337
  - *bigelovii* 338
  - *knowltonii* 338
  - *lambertii* 340
    - *sericeus* 340
  - *majusculus* 340
  - *metcalfei* 338
  - *minor* 338
  - *multiceps* 338
    - *minor* 338
  - *oreophilus* 339
  - *parryi* 339
  - *patens* 338
  - *viscidus* 340
- *Aspalathus*
  - *caragana* 307
- Astragalus 232
  - *aboriginum* 264
  - adanus 261
  - adsurgens 261
    - robustior 262
  - agrestis 262
    - *polyspermus* 262
  - alpinus 262
  - amphioxys 262
    - amphioxys 263
    - *cymbellus* 273
    - *melanocalyx* 263
    - vespertinus 263
  - ampullarius 263
  - *angustus* 268
    - *ceramicus* 268
    - *pictus* 268
  - araneosus 285
  - aretioides 264
  - *arctus* 297
  - *arietinus* 270
  - argillosus 278
  - argophyllus 263
    - argophyllus 264
    - *cnicensis* 264
    - martinii 264
    - *panguicensis* 264
    - *pephragmenoides* 264
  - *arrectus* 277
    - *eremiticus* 277
  - *artemisiarum* 265
  - *artipes* 293
  - asclepiadoides 264
  - australis 264
  - barnebyi 265
  - beckwithii 265
    - beckwithii 265
    - purpeueus 265
  - bigelovii 290
    - thompsonae 290
  - *bisontum* 338
    - *minor* 338
  - bisulcatus 266
    - bisulcatus 266
    - haydenianus 266
    - major 266
  - bodinii 266
    - *yukonis* 266
  - brandegei 267
  - brevicaulis 268
  - bryantii 267
  - *caespitosus* 301
  - callithrix 267
  - calycosus 268
    - calycosus 268
    - mancus 268
    - scaposus 268
  - *campestris* 337
    - *diversifolius* 274
  - candensis 268
    - brevidens 268
    - canadensis 268
  - *candicans* 268
  - *canovirens* 271
  - *carltonii* 290
  - *carolinianus* 268
  - castaneiformis 271
    - consobrinus 271
  - ceramicus 268
    - *pictus* 268
  - chamaeleuce 269
    - *panguicensis* 264
  - chloodes 270
  - cibarius 270
  - *cicadae* 269
    - *laccoliticus* 269
  - cicer 270
  - coltonii 271
    - *aphyllus* 271
    - coltonii 271
    - *foliosus* 271
    - moabensis 271
  - *confertiflorus* 279
    - *flaviflorus* 279
  - consobrinus 271
  - convallarius 272
    - convallarius 272
    - *diversifolius* 274
    - finitimus 272
  - cottamii 272
  - *coulteri* 285
    - *fremontii* 285
  - cronquistii 272
  - *curtilobus* 303
  - cymboides 273
  - *dasyglottis* 262
  - *debilis* 266
  - *decumbens* 289
    - *oblongifolius* 289
  - *deflexus* 337
  - desereticus 273
  - desperatus 273
    - *conspectus* 265
    - *petrophilus* 273
  - detritalis 274
  - *deihlii* 279
  - *diphysus* 285
    - *albiflorus* 285
  - diversifolius 274
    - *junceus* 272
    - *roborum* 272
  - *dodgeanus* 305
  - drummondii 274
  - duchesnensis 275
  - eastwoodae 275
  - *elegans* 277
  - emoryanus 275
  - ensiformis 276
    - *gracilior* 276
  - episcopus 276
  - eremiticus 277
  - eucosmus 277
  - eurekensis 277
  - falcatus 278
  - *fallax* 280
  - *familicus* 280
  - flavus 278
    - argillosus 278
    - candicans 278
    - flavus 279
  - flexuosus 279
    - diehlei 279
    - flexuosus 279
  - *fremontii* 285
  - fucatus 279
  - *garrettii* 290
  - geyeri 279
  - gilviflorus 280
  - *glareosus* 298
  - *goniatus* 262
  - *gracilentus* 280
    - *fallax* 280
  - hallii 280

  fallax 280
hamiltonii 280
harrisonii 281
haydenianus 266
  major 266
henrimontanensis 281
humistratus 281
humivagans 282
hylophilus 289
  oblongifolius 289
hypoglottis 262
  polyspermus 262
ibapensis 274
impensis 283
inflexus 298
  glareosus 298
iodanthus 282
  diaphanoides 282
iselyi 282
jejunus 282
jessiae 283
junceus 272
  attenuatus 272
  diversifolius 274
  orthocarpus 274
junciformis 272
kaibensis 276
kentrophyta 282
  coloradoensis 283
  elatus 283
  jessiae 283
  implexus 283
  rotundus 283
lambertii 338
  bigelovii 338
lancearius 283
lentiginosus 284
  albiflorus 285
  araneosus 285
  chartaceus 285
  diphysus 285
  fremontii 285
  palans 285
  platyphyllidius 286
  salinus 286
  scorpionis 286
  stramineus 286
  ursinus 286
  vitreus 286
  wahweapensis 286
limnocharis 287
loanus 287
lonchocarpus 287
lutosus 288
macer 287
malacoides 288
mancus 268
marcus-jonesii 263
marianus 288
megacarpus 289
  caulescens 293
  parryi 289
  prodigus 289
minthorniae 276
  gracilior 276
miser 289
  oblongifolius 289
  tenuifolius 290
missouriensis 290
  amphibolus 290
moencoppensis 290
mollissimus 290
montanus 283
  coloradoensis 283
  impensus 283
  tegetarius 283
montii 291
monumentalis 291
mortonii 268
  brevidens 268
multicaulis 297
multiflorus 303
munzii 339
musiniensis 291
  newberryoides 291
nelsonianus 291
newberryi 292
  castoreus 292
  wardianus 287
nidularius 292
nitidus 261
  robustior 261
nuttallianus 292
  imperfectus 293
  micranthiformis 293
oophorus 293
  artipes 293
  caulescens 293
  lonchocalyx 293
oreophilus 339
oroboides 271
  americanus 277
palans 285
  araneosus 285
panguicense 264
pardalinus 293
parryanus 339
pattersonii 294
  praelongus 296
peabodianus 297
pectinatus 291
  platyphyllus 291
perianus 294
pictus 268
  angustus 268
  foliolosus 268
  magnus 268
pinonis 295
platytropis 295
praelongus 295
  ellisiae 296
  lonchopus 296
  praelongus 296
preussii 296
  arctus 297
  eastwoodae 275
  latus 297
  laxiflorus 297
  laxispicatus 297
  preussii 297
  sulcatus 275, 297
procerus 296
pubentissimus 297
  peabodianus 297
  pubentissimus 297
purshii 297
  glareosus 298
  interior 298
  purshii 298
pygmaeus 269
  laccoliticus 268
racemosus 298
  treleasei 298
rafaelensis 298
sabinarum 264
sabulonum 299
sabulosus 299
salinus 286
saurinus 299
scaposus 268
scobatinatulus 266
scopulorum 300
sericoleucous 264
  arctioides 264
serotinus 272
  campestris 272
serpens 300
sesquiflorus 300
  brevipes 300
shortianus 263
  brachylobus 303
  minor 263
sileranus 302
  cariacus 302
simplex 301
simplicifolius 301
  spatulatus 301
spatulatus 301
  simplex 301
  uniflorus 301
spectabilis 274
stocksii 281
straturensis 301
striatiflorus 301
striatus 261
subcinereus 279, 302
  basalticus 302
  subcinereus 303
syrticolus 290
tegetarius 283
  elatus 283
  implexus 283
  rotundus 283
tenellus 303
  strigulosus 303
tephrodes 303
  brachylobus 303
tetrapterus 303
thompsonae 290
toanus 304
triphyllus 280
uintensis 264
ursinus 276, 286
utahensis 304
vespertinus 263
virgineus 298
viridis 283
  impensus 283
viscidus 340
wardii 304
webberi 270
  cibarius 270
wetherillii 305
wingatanus 305
  dodgeanus 305
woodruffii 306
yukonis 266
zionis 306
Atelophragma
  elegans 277
  ibapense 274
  straturense 301
Batiodophaca
  desperata 273
  humivagans 281
  petrophila 273
  sabinarum 264
  sesquiflora 300
Caesalpinia 306
  gilliesii 307
  repens 315
Caragana 307
  arborescens 307
  caragana 307
  inermis 307
sibirica 307
Cercis 307
  canadensis 307
  occidentalis 308
    orbiculata 308
  orbiculata 308
Cladrastis 308
  kentukea 308
  lutea 308
  tinctoria 308
Cnemidophacos
  argillosus 279
  confertiflorus 279
  flavus 279
  flaviflorus 279
  moencoppensis 290
  rafaelensis 298
  toanus 304
Colutea 308
  arborescens 308
Coronilla 309
  varia 309
Cystium
  araneosum 285
  cicer 270
  diphysum 285
  fremontii 285
  platyphyllidium 286
  platytrope 295
  salinum 286
  scorpionis 286

  - *stramineum* 286
- Cytisus 309
  - *laburnum* 315
  - scoparius 309
- Dalea 309
  - *amoena* 347
    - *pubescens* 347
  - *arborescens* 347
  - *candida* 311
    - *oligophylla* 311
  - epica 310
  - flavescens 310
  - *fremontii* 348
    - *minutifolia* 348
    - *pubescens* 347
  - *johnsonii* 348
  - lanata 311
    - terminalis 311
  - *numularia* 348
  - oligophylla 311
  - *polyadenia* 348
  - searisiae 311
  - *terminalis* 311
  - *whitingii* 349
- *Diholcos* 266
  - *bisulcatus* 266
  - *haydenianus* 266
  - *scobatinatulus* 266
- *Ervum* 303
  - *multiflorum* 303
- *Erythrostemon* 307
  - *gilliesii* 307
- Galega 312
  - officinalis 312
- *Genista*
  - *juncea* 351
- Gleditsia 312
  - triacanthos 312
- *Glycine*
  - *floribunda* 362
- Glycyrrhiza 312
  - lepidota 312
- *Guilandina*
  - *dioica* 313
  - *canadensis* 313
- Gymnocladus 313
  - dioica 313
- *Hamosa*
  - *atratua* 301
  - *calycosa* 268
  - *emoryana* 275
  - *ensiformis* 276
  - *imperfecta* 292
  - *manca* 268
  - *scaposa* 268
- Hedysarum 313
  - boreale 313
    - boreale 314
    - *cinerascens* 314
    - gremiale 314
    - *obovatum* 314
    - *utahense* 314
  - *canescens* 314
  - *carnulosum* 314
  - *cinerascens* 314
  - *gremiale* 314
  - *lancifolium* 314
  - *mackenziei* 314
    - *canescens* 314
    - *pubulare* 314
  - *marginatum* 314
  - occidentale 314
    - canone 314
  - *onobrychis* 335
  - *pabulare* 314
    - *rivulare* 314
  - *uintahense* 314
  - *utahense* 314
- Hoffmanseggia 315
  - repens 315
- *Homalobus*
  - *brachycarpus* 301
  - *caespitosus* 301
  - *campestris* 272
  - *canescens* 301
  - *canovirens* 271
  - *coltonii* 271
  - *detritalis* 274
  - *episcopus* 276
  - *flexuosus* 279
  - *humilis* 289
  - *junceus* 272
  - *junciformis* 272
  - lancearius 283
  - *macrocarpus* 287
  - *multiflorus* 303
  - *oblongifolius* 289
  - *orthocarpus* 274
  - *paucijugus* 290
  - *strigulosus* 303
  - *tegetarius* 283
  - *tenellus* 303
  - *tenuifolius* 290
  - *uniflorus* 301
  - *wingatanus* 305
  - *woodruffii* 306
- *Hosackia*
  - *rigida* 320
    - *numularia* 320
  - *subpinnata* 320
  - *wrightii* 321
- *Jonesiella* 297
  - *arcta* 297
  - *asclepiadoides* 264
  - *ellisiae* 296
  - *pattersonii* 294
  - *praelonga* 296
  - *sabulosa* 299
- *Kentrophyta*
  - *coloradoensis* 283
- *Kraunia*
  - *floribunda* 362
- *Kuhnistera*
  - *candida* 311
    - *diffusa* 311
    - *occidentalis* 311
  - *flavescens* 310
  - *occidentalis* 311
  - *oligophylla* 311
  - *searlsiae* 311
- Laburnum 315
  - anagyroides 315
  - *vulgare* 315
- Lathyrus 315
  - arizonicus 317
  - brachycalyx 316
    - brachycalyx 316
    - eucosmus 316
    - zionis 317
  - *bradfieldianus* 318
  - *coriaceus* 317
  - *dissitifolius* 361
  - *eucosmus* 316
  - *laetivirens* 317
  - lanzwertii 317
    - arizonicus 317
    - laetivirens 317
    - lanzwertii 317
  - latifolius 317
  - *linearis* 361
  - odoratus 317
  - pauciflorus 318
    - utahensis 318
  - sylvestris 318
  - *utahensis* 318
  - *zionis* 317
- Lespedeza 318
  - *thunbergii* 318
- *Lonchophaca*
  - *duchesnensis* 275
  - *kaibensis* 276
  - *macra* 287
  - *macrocarpa* 287
- *Lotodes* 345
  - *ellipticum* 345
- Lotus 318
  - *argensis* 320
  - corniculatus 319
    - *tenuifolius* 320
  - humistratus 319
  - longebracteatus 320
  - *numularius* 320
  - *numulus* 320
  - ridigus 320
    - x utahensis 320
  - subpinnatus 320
  - tenuifolius 320
  - tenuis 320
  - utahensis 321
  - *wrangelianus* 320
  - wrightii 321
- Lupinus 321
  - *aduncus* 327
  - *aegra-ovium* 332
  - alpestris 324
  - *alsophilus* 326
  - ammophilus 324
  - arbustus 324
    - calcaratus 324
  - *arcticus* 330
    - *prunophilus* 330
  - argenteus 324
    - argenteus 325
    - boreus 326
    - moabensis 326
    - parviflorus 326
    - rubricaulis 326
    - *stenophyllus* 326
    - tenellus 326
  - *argentinus* 327
  - *argillaceus* 329
  - *argophyllus* 327
  - *aridus* 327
    - *utahensis* 327
  - *barbiger* 331
  - brevicaulis 326
  - caespitosus 327
  - calcaratus 324
  - *capitatus* 329
  - caudatus 327
    - argophyllus 327
    - caudatus 327
    - cutleri 328
    - *rubricaulis* 326
  - *columbianus* 329
  - concinnus 328
    - orcuttii 328
  - *cutleri* 328
  - *decumbens* 327
    - *argophyllus* 327
  - *eatonanus* 329
  - *egglestonianus* 332
  - flavoculatus 328
  - *flexuosus* 332
  - *foliosus* 326
    - *stenophyllus* 326
  - *garrettianus* 325
  - *helleri* 327
  - hillii 328
  - *holosericeus* 327
    - *utahensis* 327
  - *huffmanii* 332
  - *intermontanus* 331
  - jonesii 328
  - kingii 329
    - argillaceus 329
    - kingii 329
  - *larsonanus* 332
  - *latifolius* 329
    - *columbianus* 329
  - *laxiflorus* 324, 327
    - *argophyllus* 327
    - *calcaratus* 324
    - *tenellus* 326
  - *lepidus* 327
    - *caespitosus* 327
    - *utahensis* 327
  - leucophyllus 329
  - *leucanthus* 331
  - *lupinus* 321
  - maculatus 329
  - *marianus* 332
  - *micensis* 328
  - *odoratus* 328
    - *flavoculatus* 325
    - *rubens* 331

  orcuttii 328
  palmeri 330
  parviflorus 326
  polyphyllus 330
    prunophilus 330
  prunophilus 330
  pulcher 328
  puroviridis 332
  pusillus 330
    intermontanus 331
    pusillus 331
    rubens 331
  quercus-jugi 332
  rickeri 332
  rubens 331
    flavoculatus 328
  rubricaulis 326
  salinensis 332
  sericeus 331
    barbiger 331
    flexuosus 332
    huffmanii 332
    marianus 332
    sericeus 332
  sileri 329
  sparsiflorus 332
    mohavensis 332
  spathulatus 326
    boreus 326
  stenophyllus 326
  tenellus 326
  tooelensis 330
  utahensis 327
  volutans 332
  watsonii 327
  wyethii 332
    prunophilus 330
Medicago 333
  falcata 333
  hispida 334
  lupulina 333
  polymorpha 334
  sativa 334
Melilotus 334
  albus 334
  indicus 335
  officinalis 335
Moparia
  repens 315
Onobrychis 335
  onobrychis 335
  sativa 335
  viciifolia 335
Orophaca 280
  triphylla 280
Oxytropis 335
  besseyi 337
    obnapiformis 337
  bilocularis 338
  campestris 337
    cusickii 337
    viscida 340
  cusickii 337
  deflexa 337
    deflexa 337
    sericea 338
  jonesii 338
  lambertii 338
    bigelovii 338
    sericea 340
  minor 338
  multiceps 338
    minor 338
  obnapiformis 337
  oreophila 339
    juniperina 339
    oreophila 339
  parryi 339
  patens 338
  sericea 340
    sericea 340
  viscida 340
    viscida 340
Parosela
  amoena 347
  arborescens 347
  fremontii 348
  johnsonii 348
    minutifolia 348
    pubescens 347
  lanata 311
  polyadenia 348
  terminalis 311
  thompsonae 349
Parryella 340
  filifolia 340
Pediomelum
  megalanthum 345
  mephiticum 345
  retrorsum 345
Petalostemon
  candidus 311
    oligophyllus 311
  flavescens 310
  gracilis 311
    oligophyllus 311
  occidentalis 311
  oligophyllus 311
  searlsiae 311
  sonorae 311
  truncatus 311
Peteria 341
  nevadensis 341
  thompsonae 341
Phaca
  ampullaria 263
  annua 279
  argophylla 280
  artemisiarum 265
  artipes 293
  beckwithii 265
  bisulcata 266
  bodinii 266
  caespitosa 280
  convallaria 272
  eastwoodae 275
  elegans 277
  flexuosa 279
  glareosa 298
  jejuna 282
  laxiflora 297
  macrocarpa 287
  mollissima 304
    utahensis 304
  pardalina 293
  picta 268
  platytropis 295
  preussii 297
  pubentissima 297
  purshii 298
  pygmaea 269
  sabulonum 299
  salsula 351
  serpens 300
  silerana 302
  subcinerea 302
  wardii 304
  wetherillii 305
  yukonis 305
Phacomene
  artemisiarum 265
  beckwithii 265
Phacopsis
  pattersonii 294
  praelongus 296
Phaseolus 341
  vulgaris 341
Pisophaca
  diehlii 279
  familica 280
  flexuosa 279
  pinonis 295
Pisum 341
  sativum 342
Poinciana
  gilliesii 307
Prosopis 342
  chilensis 342
  glandulosa 342
    torreyana 342
  juliflora 342
    torreyana 342
  odorata 342
  pubescens 342
Psoralea 343
  aromatica 344
  bigelovii 346
  elliptica 345
  epipsila 344
  floribunda 346
  juncea 344
  lanceolata 344
    lanceolata 345
    stenophylla 345
    stenostachys 345
  laxiflora 345
  megalantha 345
  mephitica 345
    retrorsa 345
  micrantha 345
  obtusiloba 346
  pariensis 346
  rafaelensis 344
    magna 344
  retrorsa 345
  stenostachys 345
  stenophylla 345
  tenuiflora 346
    bigelovii 346
Psoralidium
  bigelovii 346
  floribundum 346
  junceum 344
  lanceolatum 345
  micranthum 345
  stenophylla 345
  stenostachys 345
  tenuiflorum 346
Psorodendron
  amoenum 347
  arborescens 347
  fremontii 348
  johnsonii 348
  pubescens 347
Psorothamnus 347
  arborescens 347
    pubescens 347
  fremontii 347
  polyadenius 348
    jonesii 348
    polyadenius 348
  thompsonae 348
    thompsonae 349
    whitingii 349
Pterophacos
  tetrapterus 303
Robinia 349
  breviloba 349
  caragana 307
  hispida 349
  luxurians 349
  neomexicana 349
    luxurians 349
  pseudoacacia 350
  subvelutina 349
Rydbergiella
  arcta 297
  pattersonii 294
  praelonga 296
  preussii 297
Sophora 350
  japonica 350
  kentukea 308
  nuttalliana 350
  sericea 350
  stenophylla 351
Spartium 351
  junceum 351
Sphaerophysa 351
  salsula 351
Spiesia
  lambertii 340
    sericea 340
  multiceps 338
  oreophila 339
  parryi 339

  viscida 340
Strombocarpa
  pubescens 342
Swainsona
  salsula 351
Thermopsis 352
  montana 352
    ovata 352
  ovata 352
  pinetorum 352
  rhombifolia 352
Tium
  atratiforme 301
  desperatum 273
  drummondii 274
  palans
  scopulorum 300
Tragacantha
  ampullaria 263
  beckwithii 265
  bisulcata 266
  caespitosa 301
  calycosa 268
  campestris 272
  diphysa 285
  drummondii 274
  episcopa 276
  flaviflora 279
  glareosa 298
  haydeniana 266
  iodantha 282
  jejuna 282
  juncea 272
  lonchocarpa 287
  megacarpa 289
  multiflora 303
  pattersonii 294
  picta 268
  platytropis 295
  preussii 297
  pubentissima 297
  purshii 298
  pygmaea 269
  scopulorum 300
  sesquiflora 300
  tegetaria 283
  thompsonae 290
  triphylla 280
  utahensis 304
Trifolium 352
  andersonii 354
    friscanum 355
  andinum 356
  beckwithii 357
  brachypus 358
  confusum 358
  dasyphyllum 358
    uintense 356
  eriocephalum 356
    villiferum 356
  fimbriatum 359
  fragiferum 356
  gymnocarpon 356
    gymnocarpon 357
    plummerae 357
    subcaulescens 357
  heterodon 359
  hybridum 357
  inequale 359
  involucratum 359
    fimbriatum 359
  kingii 357
    macilentum 358
  longipes 357
    brachypus 358
    pygmaeum 358
    reflexum 358
    rusbyi 358
  macilentum 358
  melilotus 319
    corniculata 319
  melilotus 335
    officinalis 335
  nanum 358
  nemorale 357
  oreganum 358
    brachypus 358
    rusbyi 358
    rydbergii 358
  parryi 358
    montanense 358
  plummerae 357
  pratense 359
  repens 359
  rusbyi 358
  rydbergii 358
  spinulosum 359
  subcaulescens 357
  uintense 356
  variegatum 359
  villiferum 356
  willdenovii 359
    fimbriatum 359
  wormskjoldii 359
Trigonella 360
  corniculata 360
Vicia 360
  americana 361
    americana 361
    angustifolia 361
    minor 361
    oregana 361
    truncata 361
  caespitosa 361
  dissitifolia 361
  exigua 362
  faba 361
  linearis 361
  ludoviciana 362
  oregana 361
  producta 362
  sparsifolia 361
  sylvatica 361
  thurberi 362
  trifida 361
  truncata 361
  villosa 362
Virgillia
  lutea 308
Wisteria 362
  floribunda 362
  macrobotrys 362
  macrostachya 363
Xylophacos
  amphioxys 263
  aragalloides 263
  argophyllus 264
  brachylobus 303
  cibarius 270
  cymboides 273
  eurekensis 277
  glareosus 298
  iodantha 282
  marianus 288
  melanocalyx 263
  musiniensis 291
  newberryi 292
  purshii 298
  uintensis 264
  utahensis 304
  zionis 306

NOTICE TO CONTRIBUTORS

Original manuscripts in English pertaining to the biological natural history of western North America and intended for publication in the *Great Basin Naturalist* should be directed to Brigham Young University, Stephen L. Wood, Editor, *Great Basin Naturalist*, Provo, Utah 84602. Those intended for the *Great Basin Naturalist Memoirs* should be similarly directed, but these manuscripts are not encumbered by a geographical restriction.

Manuscripts. Two copies of manuscripts are required. They should be typewritten, double spaced throughout on one side of the paper, with margins of at least one inch on all sides. Use a recent issue of either journal as a format, and the *Council of Biology Editors Style Manual, Third Edition* (AIBS 1972) in preparing the manuscript. An abstract, about 3 percent as long as the text, but not exceeding 200 words, written in accordance with Biological Abstracts guidelines, should precede the introductory paragraph of each article. Authors may recommend one or two reviewers for their article. All manuscripts receive a critical peer review by specialists in the subject area of the manuscript under consideration.

Manuscripts that are accepted and that are less than 100 printed pages in length will automatically be assigned to the *Great Basin Naturalist.* Those manuscripts larger than 100 printed pages in length will be considered for the *Memoirs* series.

Illustrations and Tables. All illustrations and tables should be made with a view toward having them appear within the limits of the printed page. Illustrations that form part of an article should accompany the manuscript. Illustrations should be prepared for reduction by the printer to either a single-column (2 5/8 inches) or double-column (5 1/2 inches) width, with the length not exceeding 7 1/2 inches.

Costs Borne by Contributor. Contributors to the *Great Basin Naturalist* should be prepared to donate from $10 to $30 per printed page toward publication of their article (in addition to reprint costs outlined in the schedule below). Authors publishing in the *Great Basin Naturalist Memoirs* may be expected to contribute $35 per printed page in addition to the cost of printed copies they purchase. No printed copies are furnished free of charge. A price list for reprints and an order form are sent with the galley proof to contributors.

Reprint Schedule of the *Great Basin Naturalist*

	2 pp.	4 pp.	6 pp.	8 pp.	10 pp.	12 pp.	Each additional 2 pp.
100 copies	$20	$24	$28	$32	$36	$40	$4
200 copies	28	32	36	40	44	48	
300 copies	36	40	44	48	52	56	

Great Basin Naturalist Memoirs

No. 1 The birds of Utah. By C. L. Hayward, C. Cottam, A. M. Woodbury, H. H. Frost. $10.

No. 2 Intermountain biogeography: A symposium. By K. T. Harper, J. L. Reveal, et al. $15.

TABLE OF CONTENTS

Utah flora: Fabaceae (Leguminosae). Stanley L. Welsh 225

THE GREAT BASIN NATURALIST

Volume 38 No. 4
December 31, 1978
Brigham Young University

MUS. COMP. ZOOL.
LIBRARY
JUN 4 1979
HARVARD
UNIVERSITY

GREAT BASIN NATURALIST MEMOIRS

Editor. Stephen L. Wood, Department of Zoology, Brigham Young University, Provo, Utah 84602.

Editorial Board. Kimball T. Harper, Botany; Wilmer W. Tanner, Life Science Museum; Stanley L. Welsh, Botany; Clayton M. White, Zoology.

Ex Officio Editorial Board Members. A. Lester Allen, Dean, College of Biological and Agricultural Sciences; Ernest L. Olson, Director, Brigham Young University Press, University Editor.

The *Great Basin Naturalist* was founded in 1939 by Vasco M. Tanner. It has been published from one to four times a year since then by Brigham Young University, Provo, Utah. In general, only previously unpublished manuscripts of less than 100 printed pages in length and pertaining to the biological natural history of western North America are accepted. The *Great Basin Naturalist Memoirs* was established in 1976 for scholarly works in biological natural history longer than can be accommodated in the parent publication. The *Memoirs* appears irregularly and bears no geographical restriction in subject matter. Manuscripts are subject to the approval of the editor.

Subscriptions. The annual subscription to the *Great Basin Naturalist* is $12 (outside the United States $13). The price for single numbers is $4 each. All back numbers are in print and are available for sale. All matters pertaining to the purchase of subscriptions and back numbers should be directed to Brigham Young University, Life Science Museum, Provo, Utah 84602. The *Great Basin Naturalist Memoirs* may be purchased from the same office at the rate indicated on the inside of the back cover of either journal.

Scholarly Exchanges. Libraries or other organizations interested in obtaining either journal through a continuing exchange of scholarly publications should contact the Brigham Young University Exchange Librarian, Harold B. Lee Library, Provo, Utah 84602.

Manuscripts. All manuscripts and other copy for either the *Great Basin Naturalist* or the *Great Basin Naturalist Memoirs* should be addressed to the editor as instructed on the back cover.

2-79 650 37344

ISSN 0017-3614

The Great Basin Naturalist

PUBLISHED AT PROVO, UTAH, BY
BRIGHAM YOUNG UNIVERSITY

ISSN 0017-3614

VOLUME 38 December 31, 1978 No. 4

EFFECT OF IRRIGATION ON SURVIVAL OF THIRD-STAGE *HAEMONCHUS CONTORTUS* LARVAE (NEMATODA: TRICHOSTRONGYLIDAE)[1]

Graham R. Bullick[2,3] and Ferron L. Andersen[2]

ABSTRACT.— During May through October 1976, samples of sheep pellets containing laboratory-reared, third-stage *Haemonchus contortus* larvae were placed on irrigated and nonirrigated pasture plots at Provo, Utah. Periodically thereafter, grass clippings, soil scrapings, and remaining pellets were collected and baermannized to determine their comparative survival from the two environments. Water was added to the irrigated plots in accordance with a weekly sprinkling regime designed to furnish sufficient moisture to maintain pasture grass in this semiarid region. Meteorologic measurements were collected daily from both irrigated and nonirrigated sections. During the year the nonirrigated section received a total of 131 mm of precipitation, whereas an additional 979 mm of water were added via sprinkling to the irrigated section. The monthly mean maximum temperature at soil surface under grass cover for the six-month study period on the irrigated section averaged 17.7 C less than on the nonirrigated section, and the corresponding soil moisture content remained 14.4 percent higher. A bioclimatograph of conditions on the nonirrigated section showed that none of the months during the year had levels of temperature and moisture which fell within the prescribed limits for optimum pasture transmission of *H. contortus*; on the irrigated section only October of the six-month study period failed to have suitable conditions for optimum pasture transmission. Larvae placed on the plots survived significantly longer and also in significantly greater numbers on the irrigated section, and irrigation enhanced the ability of larvae to migrate from pellets onto vegetation.

Irrigation is the single most important process which permits the maximum utilization of agricultural lands in semiarid regions of the western United States. Approximately 18.8 percent of all agricultural land in the United States is irrigated (Irrigation Handbook and Directory 1972), and in the state of Utah that figure approximates 63 percent (Utah Agricultural Statistics 1976). In contrast to the marked beneficial effect of irrigation throughout the world, waste water from poor irrigational practices creates suitable breeding grounds for arthropod and molluscan vectors of disease agents (Surtees 1970, World Health Organization 1950). Irrigation in semiarid regions also creates favorable microenvironments for free-living stages of helminth parasites. Stewart and Douglas (1938) stated that irrigation water and transpiration of green vegetation in pastures in central California protected the developmental stages of nematode parasites in sheep from otherwise high temperatures. Furman (1944) reported increased populations of parasitic nematodes of sheep in an irrigated region of Sacramento Valley, California. Honess and Bergstrom (1966) reported increased nematodes in cattle that grazed on irrigated pastures in Wyoming. In central Utah from 68 to 71 percent of all cattle (Fox et al. 1970) and from 90 to 96 percent of all sheep (Wright and Andersen 1972) raised on irrigated pastures harbored parasitic nematodes of at least one species.

---

[1] Supported in part by US Public Health Grant AI 10588.

[2] Department of Zoology, Brigham Young University, Provo, Utah 84602.

[3] Present address: Department of Biology, Southern Methodist University, Dallas, Texas 75275.

The study herein reported was designed to determine the effect of irrigation on the survival of infective *Haemonchus contortus* larvae on experimental pasture plots in central Utah.

Materials and Methods

A 10 by 30 m fenced plot covered with Kentucky bluegrass (*Poa pratensis*) was established in Provo, Utah, and divided into irrigated and nonirrigated sections. Each section was further divided into rows of 14 plots, each 50 cm square and delineated as described by Andersen et al. (1970). Grass cover was mowed each week to an approximate height of 7 cm to simulate natural grazing conditions. Meteorological measurements from both irrigated and nonirrigated sections were monitored through instrumentation and procedures described by Andersen et al. (1974) and tabulated by computer programs described by Andersen and Roper (1975).

To secure infective larvae for the experiments, a sheep was given orally 12,000 third-stage *H. contortus* larvae. After the infection was patent, fecal pellets containing unembryonated eggs were collected from the sheep and incubated in the laboratory at 23 to 24 C and 100 percent relative humidity (RH) for one week until third-stage larvae developed. After incubation the pellets were divided into 30 samples of 40 grams each. Two samples were retained as controls in the laboratory to determine the average number of larvae which could be recovered following baermannization. The remaining 28 samples were distributed on the plots. One sample was placed in the grass on each of the 14 plots along one row of the irrigated section and one row of the nonirrigated section.

Experiments were started each Monday from May through October, which is the time period generally corresponding to the irrigation schedule used in Utah. For the first four days and weekly thereafter, grass clippings, soil scrapings, and remaining pellets were collected from each plot where fecal pellets containing infective larvae had been placed. Each sample was baermannized separately, and free-living nematodes in the recovered material were killed through the addition of HCl (Shorb 1937). The percentage recovery of larvae from each plot and each time interval was determined by dividing the average number of larvae recovered from the two control samples into the total number of larvae recovered from the grass, soil, and pellets.

Irrigation was performed each week from May through October by an oscillating sprinkler. The total depth of water (in mm)

Table 1. Relationship of meteorological conditions to survival of *Haemonchus contortus* third-stage larvae on irrigated and nonirrigated pasture plots, Provo, Utah, 1976.

	Temperature °C												
		Irrigated						Nonirrigated					
	Weather shelter	Soil surface under 7–10 cm grass cover			Soil surface bare ground			Soil surface under 7–10 cm grass cover			Soil surface bare ground		
Month	(Mean)	(Max.	Min.	Mean)	(Max.	Min.	Mean)	(Max.	Min.	Mean)	(Max.	Min.	Mean)
Jan	−3.4	−0.8	−1.8	−1.3	1.8	−1.6	0.1	0.7	−1.4	−0.3	2.7	−2.1	0.3
Feb	1.7	1.1	−0.9	0.1	9.6	−1.0	4.3	6.3	0.1	3.2	12.0	−1.7	5.2
Mar	2.1	7.4	0.9	4.1	22.2	0.7	11.5	14.0	0.6	2.3	25.9	−1.7	12.1
Apr	8.6	14.9	5.2	10.0	33.4	3.2	18.3	20.4	6.1	13.3	39.2	3.1	21.2
May	15.8	25.2	12.3	18.8	42.1	9.2	25.7	36.6	12.4	24.5	55.2	9.1	32.1
Jun	16.2	25.4	13.6	19.5	44.9	10.7	27.8	40.4	14.1	27.2	54.9	10.0	32.5
Jul	21.2	31.0	18.3	24.7	50.6	15.8	33.2	51.7	18.9	35.3	63.2	16.0	39.6
Aug	19.0	26.7	16.8	21.8	42.3	13.7	28.0	52.1	16.1	34.1	60.8	13.3	37.1
Sep	16.8	24.6	13.9	19.2	46.6	12.3	29.5	45.7	13.6	26.7	52.1	11.7	31.9
Oct	8.5	16.0	6.4	9.7	25.4	4.3	14.8	28.5	5.0	16.8	33.0	3.0	18.0
Nov	3.8	8.6	2.5	5.5	16.7	1.0	8.9	21.5	0.1	10.8	24.4	−2.0	11.2
Dec	−2.0	0.6	−1.8	−0.6	8.7	−3.3	2.7	13.4	−6.1	3.7	14.8	−7.4	3.7

added to the irrigated section during each week of the following months was: May, 25; June, 38; July, 50; August, 50; September, 38; and October, 25. The sprinkling regime was designed to maintain abundant grass cover on the irrigated section during the entire pasture season. The nonirrigated section received only natural precipitation.

Results

Meteorologic data.—Table 1 is a summary of the monthly meteorologic data gathered for 1976 and provides an indication of the microclimatic conditions which existed within the irrigated and nonirrigated sections of the experimental plot. All meteorologic data for the year were monitored daily and are available upon request.

As expected, irrigation greatly enhanced the favorable conditions within the microenvironment where the infective larvae of *H. contortus* were placed by markedly reducing the maximum temperatures which occurred and by increasing the moisture content within the soil. This latter factor was further reflected in the maintenance of adequate grass cover on the irrigated section for the entire study period, whereas the grass on the nonirrigated section became sparse and turned brown after the first two months of the pasture season.

During 1976 the highest monthly mean maximum temperature recorded at soil surface under grass cover on the nonirrigated section was 52.1 C during August, which compared to 26.7 C on the irrigated section. Overall, monthly mean maximum temperatures for soil surface under grass cover on the irrigated section averaged 17.7 C less than those recorded from the nonirrigated section for the months of May through October. Temperatures recorded at soil surface level from bare ground were also consistently higher on the nonirrigated section than on the irrigated section for the entire year. Monthly mean minimum temperatures recorded from the two sections were much closer than were the corresponding maximum temperatures. Monthly mean air temperatures recorded within a standard weather shelter (1.6 m above ground level) compared more closely to the monthly mean temperatures recorded at soil surface under grass cover from the irrigated section than with any of the other temperature means given in Table 1.

Figure 1 gives the pattern of precipitation for 1976, shows the amount of water added through irrigation from May through October, and depicts the comparison of soil moisture determined gravimetrically for the irrigated and nonirrigated sections. A total of only 131 mm of precipitation was received during the year, compared with the reported normal of 402 mm (Utah Agricultural Statistics 1976). With the regime used,

Moisture Pattern				Larval Recovery			
Irrigated		Nonirrigated		Irrigated		Nonirrigated	
Pptn. and water added via sprinkling (mm)	Mean percent soil moisture	Pptn. (mm)	Mean percent soil moisture	Mean no. days 0.01 percent larvae recovered	Percent larvae recovered after one week	Mean no. days 0.01 percent larvae recovered	Percent larvae recovered after one week
27.7		27.7					
14.0		14.0					
14.5		14.5					
34.4		34.4					
107.9	20.3	7.9	7.0	61	13.8	54	8.3
159.4	16.0	7.4	5.7	43	15.6	33	2.6
251.5	17.4	1.5	5.0	50	9.1	33	2.8
206.9	25.3	6.9	3.3	60	12.3	44	1.3
162.9	16.0	10.9	2.9	45	21.9	33	3.0
130.8	19.1	5.8	3.8	31	17.6	24	3.8
0.0		0.0					
0.0		0.0					

an additional amount of 979 mm of water was added to the irrigated section in the months indicated. Overall, the monthly mean of all soil moisture determinations for the irrigated section averaged 14.4 percent more than for the nonirrigated section.

Figure 2 is a bioclimatograph of monthly mean maximum temperatures vs. precipitation for the irrigated and nonirrigated sections. The double lines inside the graph represent the limits used by Gordon (1953) to indicate the environmental conditions required for optimum pasture transmission of *H. contortus*. During five of the six months of the study period, conditions on the irrigated section were within the optimum range for transmission of the parasite, whereas at no time during the year did environmental conditions measured from the nonirrigated section come within optimum limits prescribed for *H. contortus*.

LARVAL SURVIVAL.— Twenty-six experiments were completed during this study (Figs. 3–7). The solid line on each graph represents the number of total larvae recovered at each time interval indicated from grass, soil scrapings, and remaining pellets. The dashed line represents the number of those larvae recovered from grass alone and illustrates the movement of larvae from pellets onto vegetation. Table 1 includes selected recovery data from the experiments, calculated as monthly averages for those started in each month from May through October.

In all 26 experiments, larvae placed on the irrigated section survived significantly longer (calculated from last day on which 0.01 percent of larvae could be recovered; student's t test for paired samples, $t = 6.53$; $P < 0.01$) than those larvae placed on the nonirrigated section (Table 1; Figs. 3–7). The longest average monthly survival for 0.01 percent of larvae placed on either irrigated or nonirrigated plots occurred for those experiments started in May (monthly average, 61 days and 54 days, respectively). Temperatures during May were moderate and the percent soil moisture for the nonirrigated section was the highest of the entire study period (Table 1).

The shortest period of time 0.01 percent of larvae survived on either irrigated or nonirrigated plots occurred for those experiments started in October (monthly average, 31 days and 24 days, respectively). October was the only month of the pasture season during which environmental conditions on the irrigated section did not fall within the limits of optimum pasture transmission for *H. contortus*.

As shown in Table 1, the average monthly recovery of larvae after seven days' exposure was also significantly greater (Student's

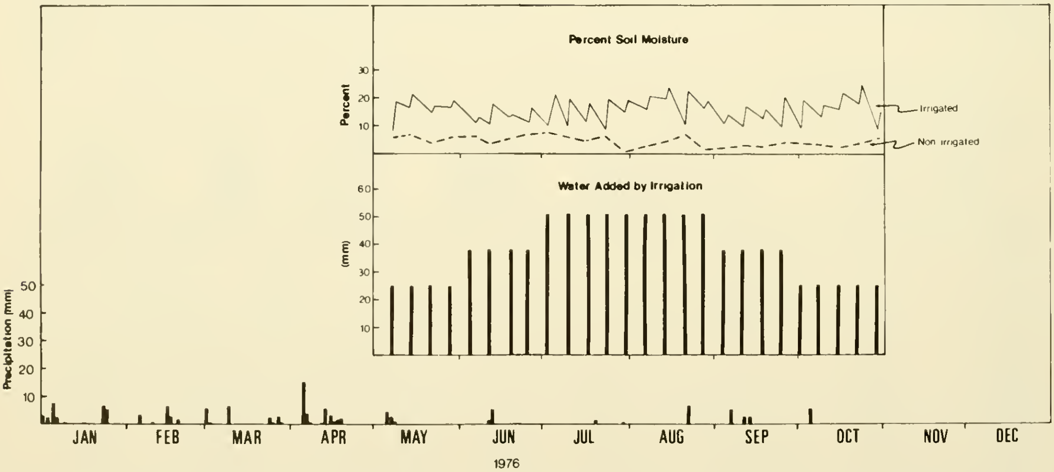


Fig. 1. Precipitation pattern, irrigation regime, and comparative soil moisture data for irrigated and nonirrigated pasture plots, Provo, Utah, 1976.

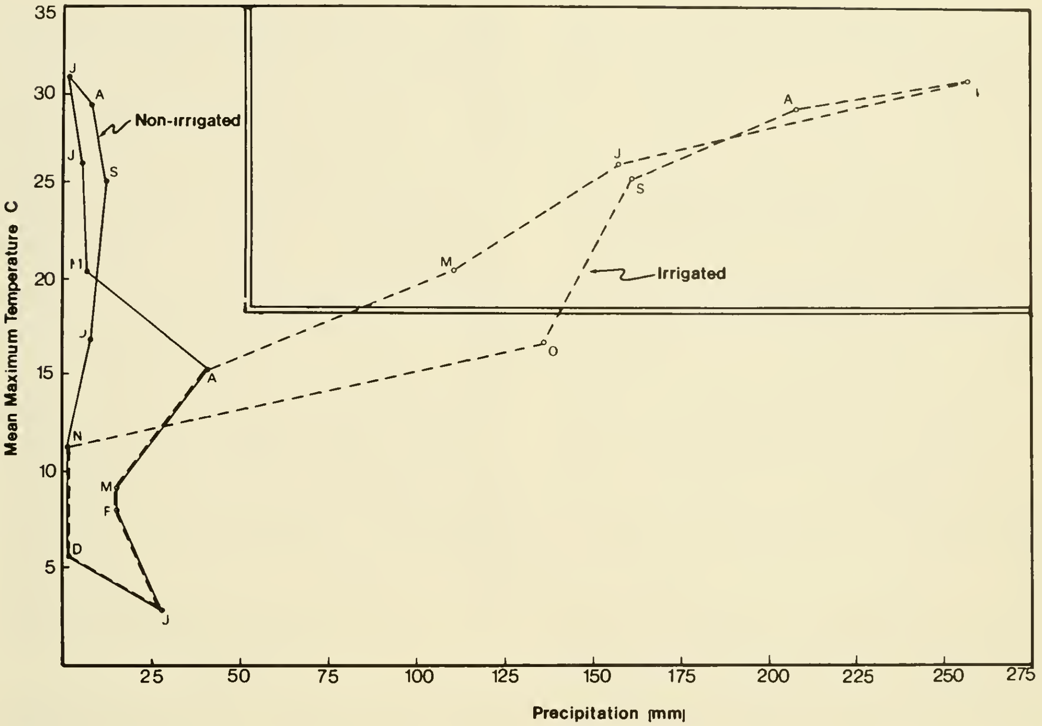


Fig. 2. Bioclimatograph of monthly mean maximum temperature vs. precipitation for irrigated and nonirrigated pasture plots, Provo, Utah, 1976.

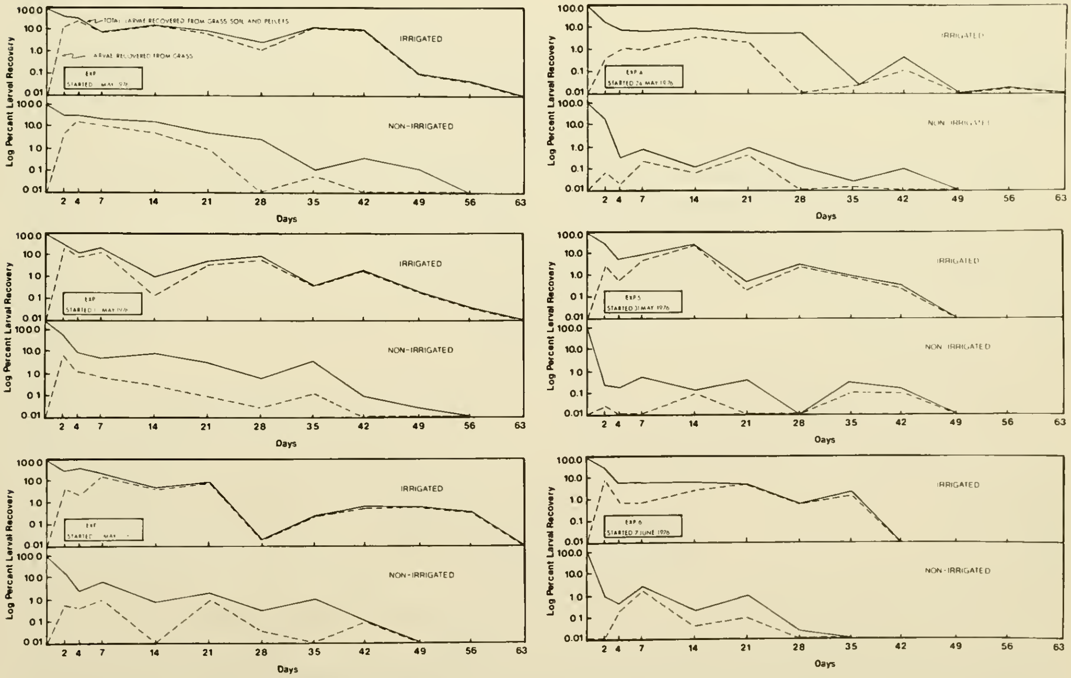


Fig. 3. Recovery of *H. contortus* third-stage larvae from irrigated and nonirrigated pasture plots, Experiments 1–6.

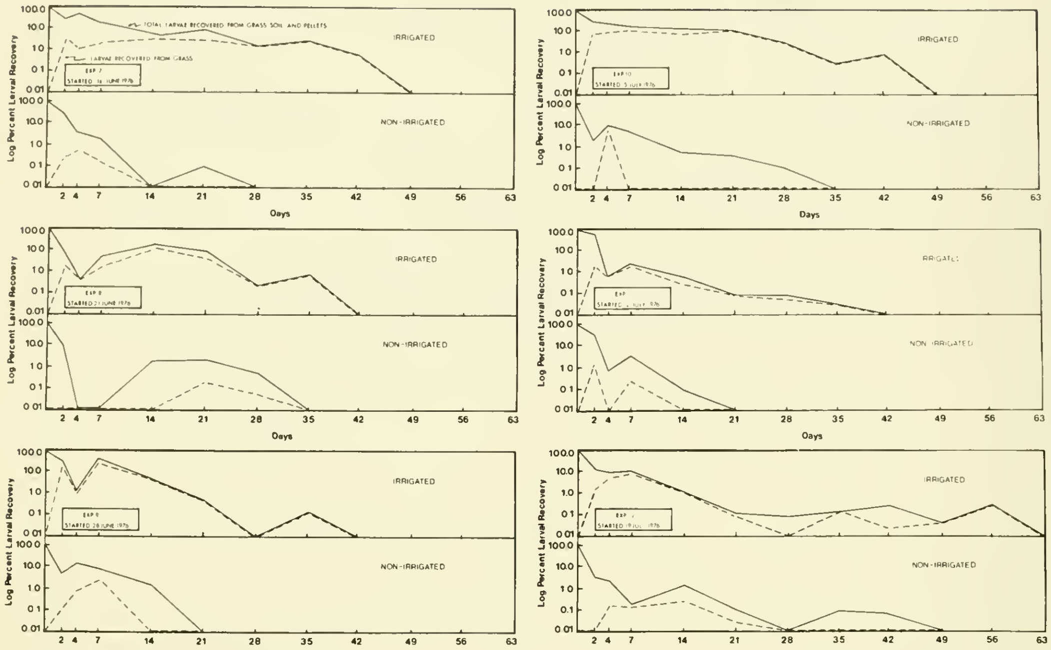


Fig. 4. Recovery of *H. contortus* third-stage larvae from irrigated and nonirrigated pasture plots, Experiments 7–12.

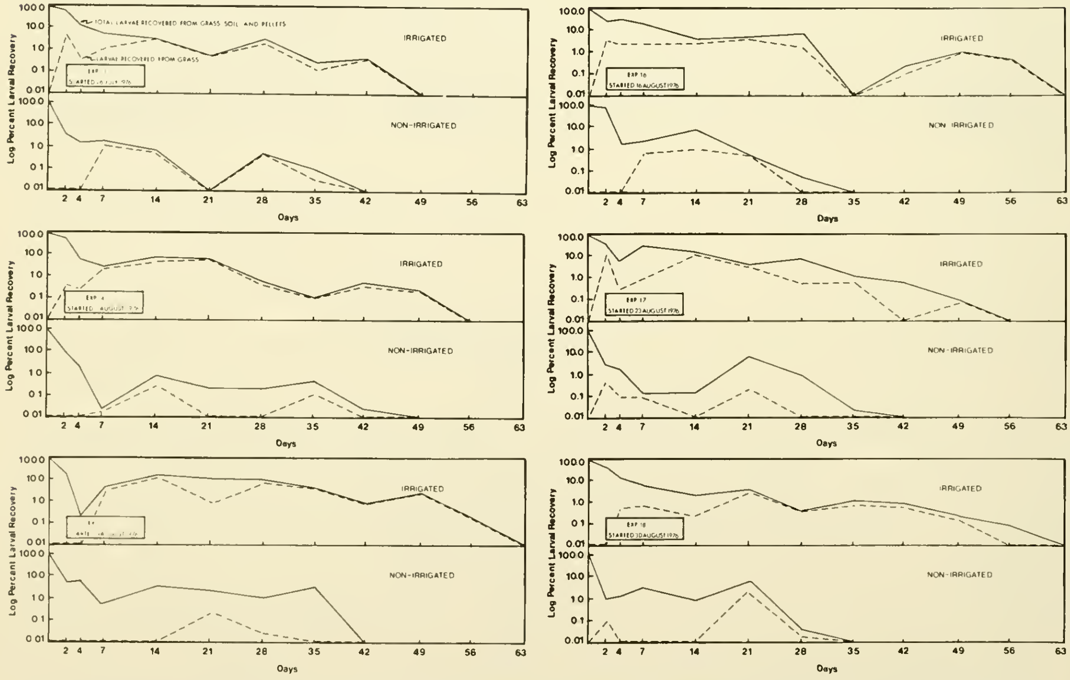


Fig. 5. Recovery of *H. contortus* third-stage larvae from irrigated and nonirrigated pasture plots, Experiments 13–18.

t test for paired samples, $t = 5.58$; $P < 0.01$) from the irrigated than from the nonirrigated section. The highest average recovery from the irrigated section at that time interval was from experiments started in September (21.9 percent) and lowest from experiments started in July (9.1 percent). The highest average recovery from the nonirrigated section after seven days' exposure was from experiments started in May (8.3 percent) and lowest from experiments started during August (1.3 percent).

Irrigation also appeared to affect the migratory ability of the infective larvae after the pellets had once been placed on the plots. After approximately seven days, larvae recovered from the irrigated plots were generally found in greater percentages from the glass clippings, whereas larvae recovered from the nonirrigated plots were generally found in greater percentages in the soil and remaining pellets (Figs. 3–7).

Discussion

Ecological studies on the free-living stages of trichostrongylid nematodes have been reported by such workers as Stewart and Douglas (1938), Levine (1963), Kates (1965), Andersen et al. (1970), Levine and Andersen (1973), Williams and Bilkovich (1973), Levine et al. (1974), Gibson and Everett (1976), and Todd et al. (1977). These individuals demonstrated that optimum conditions for development and/or survival differ between species of nematodes and that each particular species is limited generally to a unique climatic environment. Gordon (1953) reported that *H. contortus* flourishes in climatic regions where average monthly maximum temperatures exceed 18.3 C and where total monthly precipitation is above 50 mm. In our study, the addition of water by irrigation was sufficient to provide a total monthly water accumulation well in excess of 50 mm. Also, the resultant increase in soil moisture helped maintain microenvironmental temperatures within the optimum limits prescribed above. As a result, environmental conditions on the irrigated plots were within the range for optimum pasture transmission of *H. contortus* for five of the six

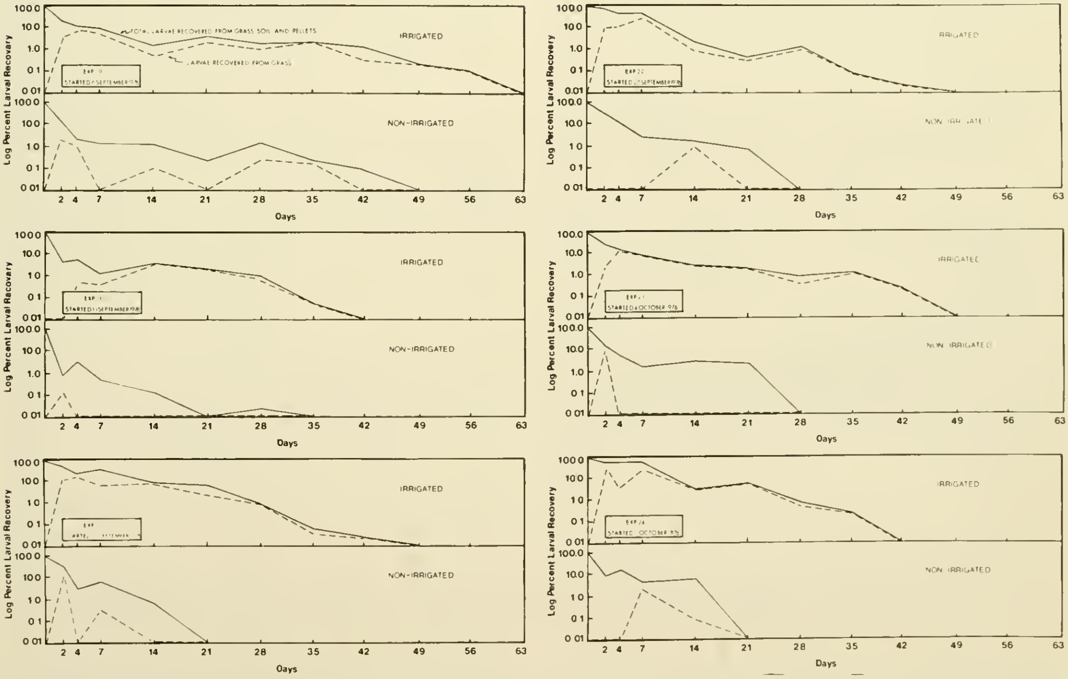


Fig. 6. Recovery of *H. contortus* third-stage larvae from irrigated and nonirrigated pasture plots, Experiments 19–24.

months of the study period. Temperatures on the nonirrigated plots, however, were usually too high for optimum larval survival and the moisture accumulation from natural precipitation alone was consistently too low.

Andersen et al. (1974) previously compared meteorologic measurements for irrigated and nonirrigated plots in the same area as the current study, and they demonstrated that the average monthly mean maximum temperatures for May through October at soil surface under grass cover for 1970, 1971, and 1972 were 23.7 and 31.1; 22.5 and 27.6; and 26.2 and 34.9 C, respectively. They further showed that the average percent soil moisture for those same months and same years from irrigated and nonirrigated plots were 16.1 and 8.4; 16.3 and 5.8; and 8.3 and 3.8 percent, respectively. The comparable figures for temperature and soil moisture content from irrigated and nonirrigated plots for the current study were 24.8 C and 19.0 percent, and 42.5 C and 4.6 percent, respectively. Some of the discrepancy from measurements taken at the same site during different years could have resulted from the fact that in the current study sprinkling irrigation was used to minimize lateral movements of the infective larvae, whereas flood irrigation was used in the 1970–72 study.

The lowering of environmental temperatures following irrigation has also been reported by such workers as DeVries and Birch (1961) in Australia, who noted a decrease during the summer of about 10 C

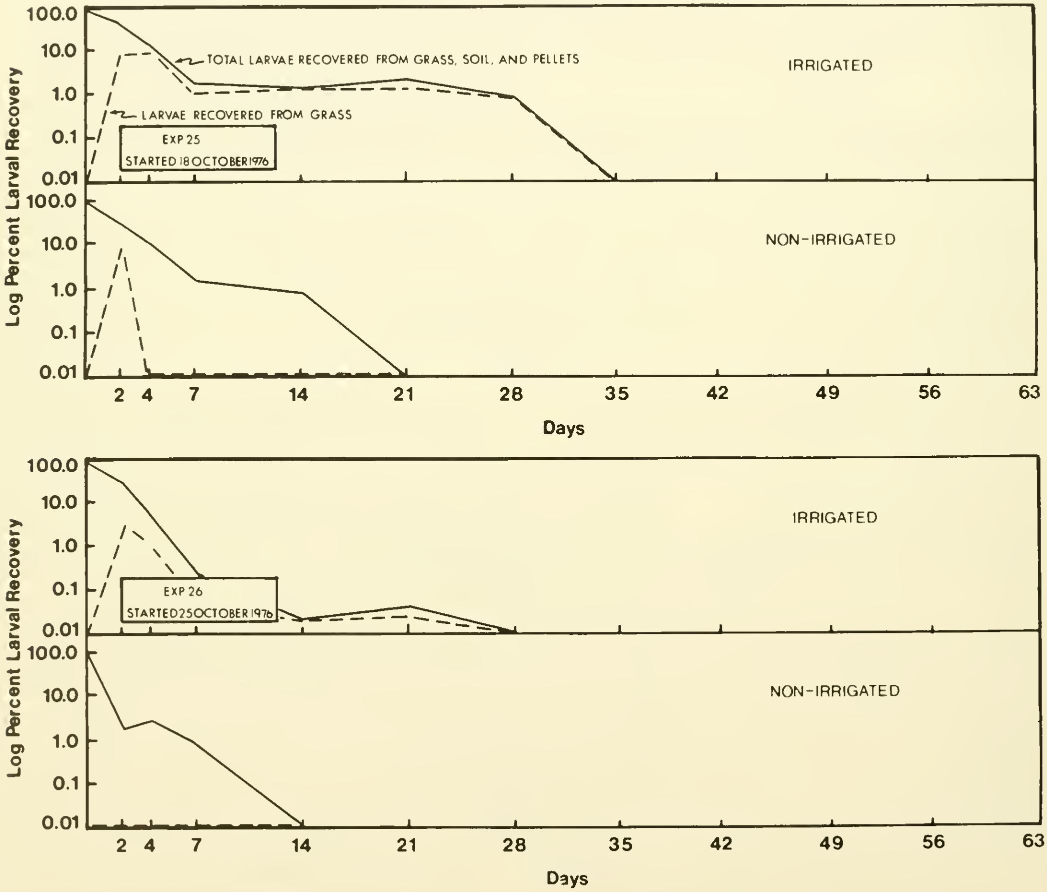


Fig. 7. Recovery of *H. contortus* third-stage larvae from irrigated and nonirrigated pasture plots, Experiments 25–26.

when the temperature was measured 5 cm below grass-covered ground, and by Leonard et al. (1971), who observed a similar decrease in an irrigated pine-covered forest in New York. Fowler and Helvey (1974) reported that air temperatures along the Columbia River Basin in Washington were well below established normals now that irrigation is so widespread in the region.

The lowering of temperatures in irrigated regions is mainly a reflection of the increased soil moisture resulting from the addition of irrigation water. Levine and Todd (1975) stated that soil moisture is a more important criterion than precipitation alone in determining optimum conditions for development and survival of *H. contortus*, since soil moisture results from an interaction of precipitation, soil type, and evapotranspiration. Soil moisture content also is the factor most responsible for the maintenance of vegetative cover. Knapp (1964) showed that different species of forage plants influenced the survival and also the infectivity of *H. contortus* in lambs. In our study, the lack of moisture on the nonirrigated section eventually killed the Kentucky bluegrass, which was subsequently replaced by a few plants with deeper tap roots. These new plants did not provide adequate cover, and soil temperatures rose drastically during ensuing months. Consequently, the pellets quickly dried and the larvae were sealed within. Andersen and Levine (1968) reported that sheep pellets routinely lose 50 percent of their original weight within 12 to 24 hr when stored at 30 C and 65 to 75 percent RH, which conditions would approximate those on our study plot. The irrigated section of the present project site maintained ample grass cover for all six months of the study period and pellets placed on the plots remained moist or disintegrated as water was added.

The number of days third-stage trichostrongylid larvae may be recovered from artificially infected pastures is not only dependent upon existing meteorologic conditions in the specific geographical location where the study occurs, but also upon the particular species of nematode studied. Gibson and Everett (1976) recovered third-stage larvae of *H. contortus* for as long as 40 weeks in England, whereas Levine et al. (1974) recovered 0.1 percent infective larvae of *H. contortus* for nine weeks in Illinois. In the present study, 0.01 percent of larvae survived on the irrigated plots for a maximum of nine weeks several times during the six-month study period and at least for a minimum of four weeks even during October, when conditions for pasture transmission were not optimum. On the nonirrigated plot, 0.01 percent of larvae were recovered for a maximum of eight weeks during May, when soil moisture content was still adequate. Thereafter, survival time dropped considerably until in October larvae were recovered for only two weeks.

In addition to an increased larval survival time on irrigated plots in the present study, an increased percentage of larvae survived on the irrigated section. Furthermore, larvae on irrigated plots were recovered almost exclusively from grass clippings after one week, whereas at that time larvae from nonirrigated plots were recovered mainly from pellets and soil scrapings. Irrigation thus aided migration of larvae from the pellets onto the vegetation, where they would be in the optimum position to be ingested by the grazing host under natural field conditions.

In summary, the present study demonstrated that irrigation enhanced the ability of *H. contortus* larvae to survive longer and in greater numbers on experimental pasture plots, and also increased their ability to migrate from pellets onto adjacent vegetation. Without suitable moisture and temperature, optimum conditions for pasture transmission would not have been achieved. Irrigational practices in Utah undoubtedly contribute to the relatively high incidence of *H. contortus* in this region where the prevailing climatic conditions indicate the parasite could not otherwise flourish.

Literature Cited

Andersen, F. L., and N. D. Levine. 1968. Effect of desiccation on survival of the free-living stages of *Trichostrongylus colubriformis*. J. Parasitol. 54: 117–128.

Andersen, F. L., N. D. Levine, and P. A. Boatman. 1970. Survival of third-stage *Trichostrongylus colubriformis* larvae on pasture. J. Parasitol. 56: 209–232.

Andersen, F. L., and P. R. Roper. 1975. Computerized reduction of meteorologic measurements from irrigated and non-irrigated plots in Central Utah. Great Basin Nat. 35: 203–230.

Andersen, F. L., P. D. Wright, and J. C. Fox. 1974. A comparison of meteorologic measurements from irrigated and nonirrigated plots, Provo, Utah, 1970–1972. Brigham Young Univ. Sci. Bull., Biol. Ser. 19: 1–37.

Devries, D. A., and J. W. Birch. 1961. The modification of climate near the ground by irrigation for pastures on the Riverine Plain. Aus. J. Agr. Res. 12: 260–272.

Fowler, W. B., and J. D. Helvey. 1974. Effects of large scale irrigation on climate in the Columbia Basin. Science 184: 121–127.

Fox, J. C., F. L. Andersen, and K. H. Hoopes. 1970. A survey of the helminth parasites of cattle and sheep in Utah Valley. Great Basin Nat. 30: 131–145.

Furman, D. P. 1944. Effects of environment upon the free-living stages of *Ostertagia circumcincta* (Stadelmann) Trichostrongylidae: II. Field Experiments. Am. J. Vet. Res. 5: 147–153.

Gibson, T. E., and G. Everett. 1976. The ecology of the free-living stages of *Haemonchus contortus*. Br. Vet. J. 132: 50–59.

Gordon, H. M. 1953. The epidemiology of helminthosis in sheep in winter-rainfall regions of Australia. I. Preliminary observations. Aust. Vet. J. 24: 17–45.

Honess, R. F., and R. C. Bergstrom. 1966. Trichostrongylosis of cattle in Wyoming. Sci. Monograph 2, Agr. Expt. Sta., Univ. Wyoming, Laramie, Wyoming.

Irrigation Handbook and Directory. 1972. Irrigation Data, Inc., Lincoln, Nebraska. 327 p.

Kates, K. C. 1965. Ecological aspects of helminth transmission in domesticated animals. Amer. Zool. 5: 95–130.

Knapp, S. E. 1964. Relationship of different species of forage to the survival and infectivity of *Haemonchus contortus* in lambs. J. Parasitol. 50: 144–148.

Leonard, R. E., A. L. Leaf, J. V. Berglund, and P. J. Craul. 1971. Annual soil moisture-temperature patterns as influenced by irrigation. Soil Sci. 3: 220–227.

Levine, N. D. 1963. Weather, climate, and the bionomics of ruminant nematode larvae. Adv. Vet. Sci. 8: 215–261.

Levine, N. D., and F. L. Andersen. 1973. Development and survival of *Trichostrongylus colubriformis* on pasture. J. Parasitol. 59: 147–165.

Levine, N. D., and K. S. Todd, Jr. 1975. Micrometeorological factors involved in development and survival of free-living stages of sheep nematodes *Haemonchus contortus* and *Trichostrongylus colubriformis*. Int. J. Biometeor. 19: 174–183.

Levine, N. D., K. S. Todd, Jr., and P. A. Boatman. 1974. Development and survival of *Haemonchus contortus* on pasture. Am. J. Vet. Res. 35: 1413–1422.

Shorb, D. A. 1937. A method of separating infective larvae of *Haemonchus contortus* (Trichostrongylidae) from free-living nematodes. Proc. Helm. Soc. Wash. 4: 52.

Stewart, M. A., and J. R. Douglas. 1938. Studies on the bionomics of *Trichostrongylus axei* (Cobbold) and its seasonal incidence on irrigated pastures. Parasitology 30: 477–490.

Surtees, G. 1970. Large-scale irrigation and arbovirus epidemiology, Kano Plain, Kenya. I. Description of the area and preliminary studies on the mosquitoes. J. Med. Ent. 7: 509–517.

Todd, K. S., Jr., N. D. Levine, and B. N. Wagher. 1977. Effects of repeated desiccation on survival of infective *Cooperia punctata* larvae. J. Parasitol. 63: 956–957.

Utah Agricultural Statistics. 1976. Utah State Department of Agriculture, Salt Lake City, Utah. 104 p.

Williams, J. C., and F. R. Bilkovich. 1973. Distribution of *Ostertagia ostertagi* infective larvae on pasture herbage. Am. J. Vet. Res. 34: 1337–1344.

World Health Organization. 1950. Joint study group on bilharziasis in Africa. Rep. 1st Sess. Tech. Rep. 17: 16.

Wright, P. D., and F. L. Andersen. 1972. Parasitic helminths of sheep and cattle in central Utah. J. Parsitol. 58: 959.

MOUNTAIN ANTS OF NEVADA

George C. Wheeler[1] and Jeanette Wheeler[1]

Abstract.— Introductory topics include "The High Altitude Environment," "Ants Recorded from High Altitudes," "Adaptations of Ants," "Mountain Ants of North America," and "The Mountains of Nevada." A Nevada mountain ant species is defined as one that inhabits the Coniferous Forest Biome or Alpine Biome or the ecotone between them. A table gives a taxonomic list of the mountain ants and shows the biomes in which they occur; it also indicates whether they occur in lower biomes. This list comprises 50 species, which is 28 percent of the ant fauna we have found in Nevada. Only 30 species (17 percent of the fauna) are exclusively montane; these are in the genera *Myrmica, Manica, Stenamma, Leptothorax, Camponotus, Lasius,* and *Formica.* The article concludes with "Records for Nevada Mountain Ants." All known records for each species are cited. For each record we give first the county, next the mountain range, then the peak (or other local feature), and finally the elevation.

Epigraphs

"The first compilation of world ants found at elevations of 2000 m (6560 ft) or more shows that, while many species may be found at the 2000 m level, the numbers decrease rapidly with increase in altitude. Few ants are found at 3000 m (9840 ft), and at 4000 m (13,129 ft) or more only nine species are known. The world altitudinal record is of *Formica picea lochmatteri* Stärcke at 4800 m. (15,740 ft) in the Himalayas" (Weber 1943: 351).

"While other branches of entomology have made great advances in recent years, our knowledge of the insect life of the North American mountains is, however, extremely fragmentary" (Mani 1968: 365).

Acknowledgments

As soon as we moved to Nevada in 1967 we began a study of the ants of the state. Most areas were readily accessible, thanks to an excellent highway system and a Jeep Wagoneer. But we soon found that we were too old for hiking and backpacking in the rarified air of the mountaintops.

To remedy this handicap, we applied for and were awarded two National Science Foundation grants to employ students to collect for us. The first was for the Alpine Biome (BMS74-13679). For this study we hired Alvin McLane (one of Nevada's most experienced mountaineers) and Jane Ramburg (a senior botany major at Wellesley College) for two months during the summer of 1975. The second grant (DEB76-11131) was for the upper levels of the Coniferous Forest Biome. For this study we hired two University of Nevada, Reno, students, Gary Nigro (a graduate entomology student) and Wendy Guyer (a senior botany major) for two months during the summer of 1977.

The above should not be taken to mean that we have had no personal experience with high-altitude ants. We have taken advantage of the excellent gravel road up to 12,000 ft on Mt. Grant (elevation 12,200 ft) near Hawthorne and a passable road up to 10,000 ft on Mount Jefferson (elevation 11,949 ft). There are also many roads up to 9000 ft, but these one-lane roads without turnouts generally lead to mines.

We thank Alvin McLane for reading the manuscript.

Definition

In his book, Mani (1968:8) preferred the term "hypsobiont" or "high altitude" to "alpine" and gives this definition: "The high altitude insects may thus be described as an ecologically highly specialized, mountain autochthonous group existing exclusively in the biome above the forest, at elevations above 2000–2500 m." None of our Nevada ants can qualify because of the adverb *exclusively*, so we will use the more modest term *alpine.*

---

[1] Adjunct Research Associates, Desert Research Institute, Reno, Nevada 89506.

The student of mountaintop faunas must be duly warned (as does Mani, p. 4) that not all insects occurring at high altitudes are hypsobionts: "Incredibly large numbers of insects [even heavy flying insects] are lifted from the lowland by warm updraft air currents to high altitudes, to be chilled dead, blown passively and eventually cast on high mountain slopes." The converse, however, is not true: hypsobionts are rarely encountered on the lowlands.

In this study we define a Nevada mountain ant species as one that inhabits the Coniferous Forest Biome or the Alpine Biome or the ecotone between them. We cannot use an elevational boundary because the lower limit of the forest is too uneven.

High-altitude Environment

The high-altitude environment, like all others, is a complex of many interrelated factors, but it differs from all others in one respect: reduced atmospheric pressure, which is itself the result of high altitude. This seems to say that the high-altitude environment is characterized by high altitude, but we shall avoid being so foolish by describing some of the effects of reduced atmospheric pressure.

1. Deficient oxygen, the most important characteristic. In the Himalaya at the timberline the oxygen is 68 percent of what it is at sea level; at 6000 m it is only 45 percent. Mountain sheep, ibexes and yaks live up to 5800 m; man without an artificial oxygen supply lives up to 8540 m. Certain insects, mites, and spiders flourish at 6800 m, because they are only slightly affected by decreased oxygen or by sudden changes in atmospheric pressure (Mani 1968:10).

2. Atmospheric cold. While it is true that cold does slow down the activities of insects, high-altitude insects can exist only because of the atmospheric cold: it enables them to withstand the atmospheric aridity (Mani 1968:22–23).

3. Atmospheric aridity.

4. Intense solar radiation. "Regardless of atmospheric temperature, objects exposed to direct sunshine warm up far more rapidly than at sea level" (Mani 1968:21). This is enormously important for insects because of the short days and the short summers.

5. Snow cover. This is absolutely essential for high-altitude insects. It prevents freezing and desiccation and, because the habitat under the snow is not frozen, makes possible an earlier start of summer activities.

6. Biotic factors. (After Mani 1968:44) Most biotic factors are ultimately based on the following:

(a) Trees are absent.
(b) The scant cespitose vegetation has a short growing period.
(c) The active feeding period is severely restricted by the short summer. In the northwestern Himalaya on south slopes the average annual feeding period may last 10 weeks at 3000–4000 m. On north slopes it starts later and is shorter.
(d) Sources of food are extremely irregular, relatively scant, and often localized.
    (1) Autochthonous sources are plants and animals normally living at high altitudes.
    (2) Wind-blown organisms from the lowlands are the predominant source and are most abundant at the melting edges of snow where dead plants and animals (mostly insects) become exposed. The surface of the snow is likewise important; it is almost the exclusive source in the Himalaya above 5000 m.
(e) Suitable microhabitats are scarce. Actually there are only two of any significance: (1) cracks in the soil and rocks and (2), of far greater importance, under stones.
(f) Crowding and isolation, caused by this scarcity, may result in "a state of . . . armed neutrality rather than peaceful coexistence!" (p. 81)
(g) The majority of high-altitude insects are predators, parasitoids, or parasites. "It would seem that almost every

member of a high-altitude community spends practically all its time devouring and predating [sic] on every other member species" (pp. 80–81).

(h) The base of the ecological pyramid is Collembola.

(i) The fauna is impoverished in number of species (perhaps to only three of four in a community), but the number of individuals per species may be very large.

ANTS RECORDED FROM HIGH ALTITUDES

Weber (1943:341–346) has assembled a list of records with locations and elevations in meters and in feet. The following totals include only workers recorded *above* 2000 m (=6560 ft), except in North America where for some unexplained reason he includes only those at or above 10,000 ft: the Himalaya 37 species, other Asiatic records 15, Alps 1, North America 16, South America 12, Africa 62.

Gregg (1963) recorded for Colorado 33 species at or above 10,000 ft. In Nevada there are 19 species at or above 10,000 ft.

Formica picea lochmatteri, which is found at an elevation of 15,749 ft in the Himalaya (Weber 1943:351), is the world's highest known ant. The Nearctic champion is apparently *Formica neorufibarbis*, which has been taken at 14,260 ft on the summit of Mt. Evans in Colorado (Gregg 1963:533). The Nevada champion is likewise *Formica neorufibarbis*, taken on Boundary Peak in Esmeralda County at 12,160 ft. (The summit of Boundary Peak is the highest elevation in Nevada: 13,145 ft.)

Deserving special mention here is *Tapinoma sessile*. Creighton (1950:353) gave its range as "southern Canada and the entire United States with the exception of desert areas in the southwest. The incidence of *sessile* appears to decrease sharply in the Gulf Coast region but it has been taken in Florida, Alabama, Mississippi and Texas." We collected it three times in Deep Canyon near Palm Desert, California (Wheeler and Wheeler 1973:106), which is in the Colorado desert. "The ants have been found to nest all the way from sea level to heights of over 10,000 feet" (Smith 1928:319). Gregg (1963:446) reported it up to 10,505 ft in Colorado. So the Nevada record of 11,320 ft on Boundary Peak must be the highest not only in Nevada but also anywhere the species is found.

ADAPTATIONS

Because the Arctic-alpine is the harshest terrestrial environment on earth, one may ask what special adaptations permit certain species to live and even thrive in it:

1. Pigmentation. The insects of high altitudes have a large amount of melanin in their integument. The black color enables them to warm up faster and earlier in the morning as well as earlier in the season. This ensures them a longer working period during the all-too-short summer.
2. Atrophy of wings. This enables them to stay in their suitable environment in spite of violent winds. (This does not apply to ants.)
3. Prolonged hibernation. Such species hibernate most of the year and sometimes for two years.
4. Subsurface life. Few species live on the surface. (This does not apply to ants, whose workers may be very active on the surface when conditions are favorable.)
5. Increased clothing. Hairs, scales, and wax are more abundant.
6. Cold stenothermy. High altitude insects are usually active at temperatures near freezing; this prevents dessication. Many develop normally at –1.5 to 5 C (31–41 F) during summer. Some will be killed in a few minutes by exposure to the warmth of a human hand.

ADAPTATIONS OF ANTS

Ants by their very nature are preadapted to life in a wide variety of environments, including some of the harshest on earth. We have discussed elsewhere (Wheeler and Wheeler 1973:7) their preadaptations to another harsh environment, the desert:

1. *Social life*: The cooperation of many individuals is advantageous anywhere in foraging, nest construction, defense, and care of the young.

2. *Nest structure*: Since ants' nests are excavated in the soil, they require no biologically expensive building materials; they are completely flexible as to plan; they are extremely efficient in that they afford a wide range of temperature and moisture conditions, from which the ants can select an optimum.

3. *Nocturnal activity*: Many species are active both day and night and, of course, all ants are able to function in the total darkness of their nests.

4. *Speed*: Many species can run rapidly. This would be especially useful in high altitudes, for there is a lot of work to be done in the short summer.

5. *Omnivorous diet*: The majority of ants are omnivorous; their food consists of insects, honeydew, seeds, and plant exudates.

6. *Integument*: One of the general adaptations of insects to life in any terrestrial environment is an integument that is relatively resistant to water loss. It also aids in the regulation of body temperature, a very important role in small, cold-blooded animals.

Are there, then, any special adaptations of ants for high altitudes? Did evolution need to do any special remodeling before ants could thrive at high altitudes? The answer is no. But color is a preadaptation that becomes especially important at high altitudes. Black and red are common ant colors in all biomes, but there are many ant colors. Among our Alpine Biome ants, however, all species are black or dark brown or a combination of red and black or red and dark brown—colors which absorb heat most rapidly, black being most efficient. Furthermore the bicolored species of *Formica* are polymorphic: the large major workers have the head and thorax (or only the thorax) red, but the gaster is black or dark brown. The smaller workers, however, become progressively more infuscated until the minims are practically black. These small minims warm up and become active earlier in the morning; the larger and redder majors begin work later. If the midday sun becomes too hot for the minims, the majors and medias can keep on working.

MOUNTAIN ANTS OF NORTH AMERICA

Ant faunas are impoverished at high altitudes. Van Pelt (1963:205) found this to be true of the much lower mountains in the Blue Ridge Province of the southeastern United States, where the highest elevation is 6684 ft: "The number of ant forms, and in most cases the numbers of colonies, decreased with increasing altitude."

W. M. Wheeler (1917:460) made much of slope: "In mountain regions slope exposure in its relation to insolation is a very important factor in the local distribution of ants. . . . Northern slopes in the northern hemisphere are usually, for very obvious reasons, almost or quite destitude of ants. . . . [Forel] finds that ants prefer the eastern and southern slopes as these are the situations in which they have the longest day for their activities during the breeding season, since they are early awakened by sufficiently high temperatures of the soil and air from the lethargy induced by the chill night hours, and even though the slope may be in the shade during the afternoon the warmth is sufficient to sustain their activities till sunset. On western slopes, however, the morning hours are too cool and are therefore practically lost to the ants, whereas the afternoon hours are too warm."

Wheeler also stressed the importance of steepness (p. 462). In front of a steep slope facing the sun the heated air rises more rapidly to greater heights before it is cooled to the general temperature of the stratum it penetrates.

Ants "always greatly prefer the more gradual slopes and alpine meadows, probably because the soil of such places retains a more abundant and more equable supply of moisture and because their surfaces are much less exposed to rapid evaporation both from direct insolation and from air-currents" (W. M. Wheeler 1917:462).

If treeless alpine environment is a harsh one, then a forest ought to be a great improvement. But this is not necessarily so. A dense forest with a solid canopy is a hostile environment. "Ecologically significant are those areas in which no ants are found. All of them are above 6000 feet, and almost all occur within forests of spruce-fir or fir" (Van Pelt 1963:221).

If dessication is such a hazard to ants, then a moist environment should be favorable. Again this is not necessarily true. Said W. M. Wheeler (1917:460): "Even moderately low temperatures, when coupled with considerable humidity, a condition which prevails in California during the winter months, is very unfavorable to ants, and when such conditions are most accentuated, the ant-fauna is reduced to a mere remnant, although the vegetation, if the temperature is not too low, may be luxuriant. This is the case in New Zealand where I sometimes searched in vain for an ant-colony in forests whose luxuriance rivalled those of the tropics. But we have a striking example of the depressing effects of cold and moisture on ant-life much nearer home. The cool Selkirk Mts. of British Columbia have an abundant supply of moisture and an unusually rich flora, but their ant-fauna is reduced to a few boreal species. The adjacent Canadian Rockies, however, though in the same latitude, are less humid and have a poorer flora, but their ant-fauna is decidedly richer in species and colonies."

The most favorable environment for mountain ants is an opening in the forest. Here the ants can find insolation or shade, whichever and whenever needed; the correct humidity may be selected; the workers can forage in the opening and/or the forest. They may nest under stones, but additional nesting sites are afforded by fallen dead trees (or branches): under bark, in solid dead wood, in rotten wood, or in the soil under the fallen trunk or branch. In the Alpine Biome they of necessity usually nest under stones, but occasionally thatching ants construct nests with plant debris.

MOUNTAINS OF NEVADA

When we were studying geography in the grades, we visualized the Great Basin as a sort of huge washpan, the bottom a flat plain bordered by mountains. Later in physiography we learned that the Great Basin was a part of the Basin and Range Province, which had mountain ranges rising up from the floor. Still later, when we drove across Nevada and saw a few low ranges, we were not properly impressed. It was only after we had begun our study of the ants of the state that we were forced to the realization that Nevada is a mountainous state. We proved it to our satisfaction by exploring all parts of the state. We were especially impressed when we stood on the summit of Grant Peak (12,200 ft) and viewed in all directions numerous mountain ranges separated by basins. Perhaps the best confirmation is to view the United States Geological Survey's large (1:500,000) relief map of the state (see fig. 1).

Nevada's topographical uniqueness lies in the fact that most of its surface consists of numerous (more than 300) short, isolated mountain ranges separated by basins—usually called valleys both by local inhabitants and on maps. The floors of some of these basins are 7000 ft above sea level. It seemed strange to us at first to call anything a "valley" if its "floor" is higher than any peak east of the Rocky Mountains (including the Black Hills as part of the Rockies).

Nevada's ranges are subparallel, and their axes generally approach a north-south direction. They are short—50–75 miles (=80–120 km) long and nearly straight. Not all of them are high, but 43 ranges have peaks between 7000 and 9000 ft; another 54 are above 9000 ft and attain a maximum of 13,140 ft on Boundary Peak.

The higher ranges show biotic zonation, because, with increasing altitude, temperature decreases and precipitation increases from 3 to 30 inches annually. The Alpine Biome (Fig. 2) may be found on the summits of a few of the higher ranges above 10,000 ft. Below the Alpine is the Coniferous Forest Biome (Fig. 3) extending from about 5000 to 11,500 ft. We are inclined to suspect that the mixed bristlecone pine (*Pinus longaeva*) and limber pine (*P. flexilis*) constitute an ecotone (Fig. 4) between the Alpine and Coniferous Forest Biomes. This is especially true of the older forests, which are widely open.

The Alpine Biome is treeless and the plants consist typically of grasses, sedges and forbs. Some of the summits are devoid of plants, having just bare rocks. They are without ants.

Billings (1954) recognized three subdivisions of the coniferous forests of Ne-

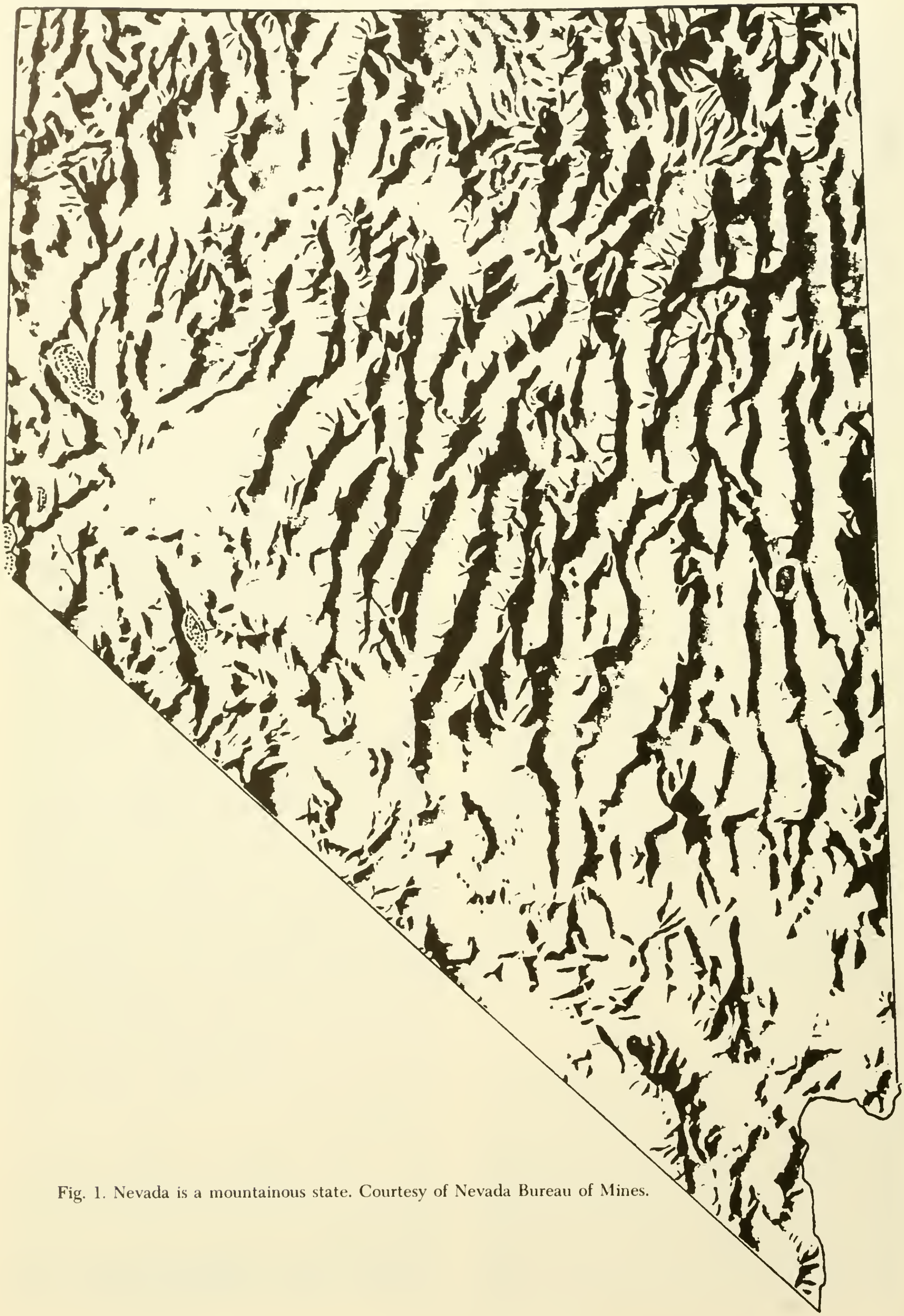


Fig. 1. Nevada is a mountainous state. Courtesy of Nevada Bureau of Mines.

vada; (1) Sierran, (2) Rocky Mountain, and (3) Great Basin.

(1) The Sierran is found only in the Carson Range a few miles south of Reno. The pine-fir zone occurs between 5000 and 7500 ft and comprises large trees from 75 to 200 ft high; it is an open forest dominated by yellow pine (*Pinus ponderosa*), Jeffrey pine (*P. jeffreyi*), and white fir (*Abies concolor*). There is an extensive understory of shrubs, etc.

The next zone (7500–9300 ft) is dominated by red fir (*Abies magnifica*) and may include lodgepole pine (*P. murrayana*), western white pine (*P. monticola*), Jeffrey pine (*P. jeffreyi*), and mountain hemlock (*Tsuga mertensiana*). Aspen (*Populus tremuloides*) often forms groves in moister places. From about 9300 ft to the timberline (about 10,300 ft) is a semi-open patchy subalpine forest. The principal tree is whitebark pine (*P. albicaulis*), which diminishes in height from about 40 ft at 9300 ft to 2 or 3 ft at timberline, where it forms the characteristic krummholz. Other trees are limber pine, lodgepole pine, and mountain hemlock.

(2) The Rocky Mountain subdivision comprises the eastern ranges from the Jarbidge Mountains in Elko County to the Spring Mountains in Clark County. The complete Rocky Mountain zonal series is (in ascending order): ponderosa pine; Douglas fir (*Pseudotsuga menziesii*), and white fir; subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*), and often limber pine or bristlecone pine. In most cases one or more zones are missing or zones may be telescoped, producing mixtures.

(3) In Billing's third division the ranges have the simplified forest zones of the Great Basin proper. The Pinyon-Juniper Biome reaches up to 7500–8500 ft. Above this is an almost treeless zone of sagebrush, mountain mahogany (*Cercocarpus ledifolia*), and other shrubs reaching 9500–10,000 ft. Above the treeless zone is an open subalpine forest of limber pine and bristlecone pines, which we regard as ecotone.

In all zones of all three subdivisions mountain streams are bordered by aspen,

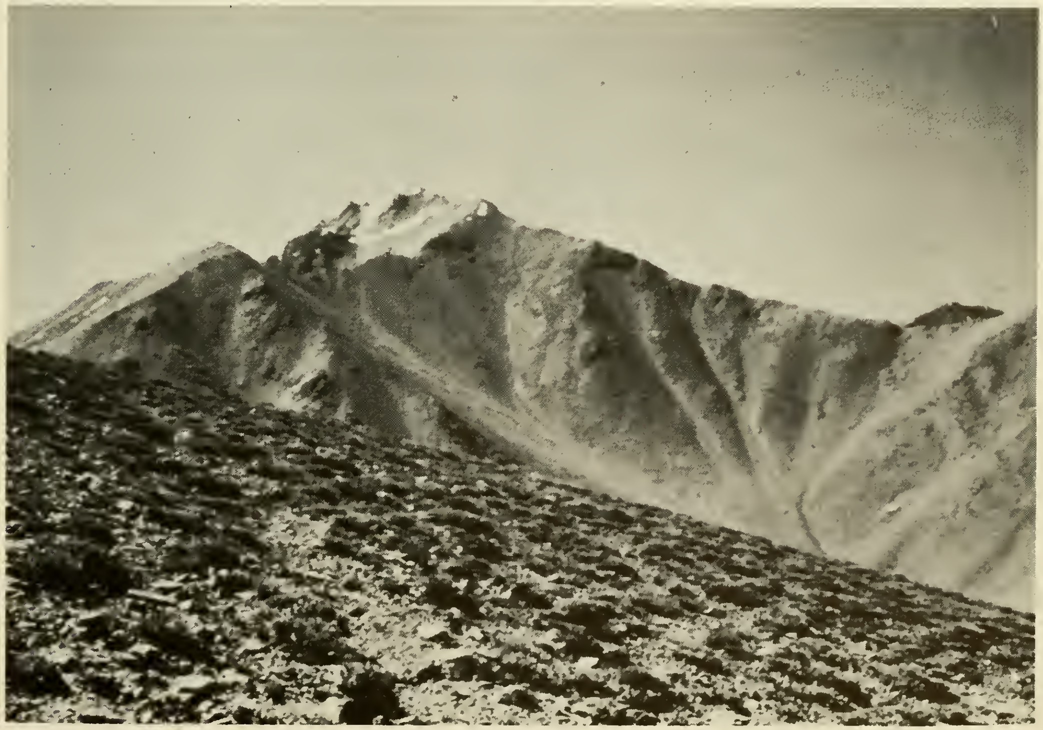


Fig. 2. Alpine Biome. Foreground with typical mat vegetation. Esmeralda County: Summit of Boundary Peak in background. Photograph by Gary Nigro.

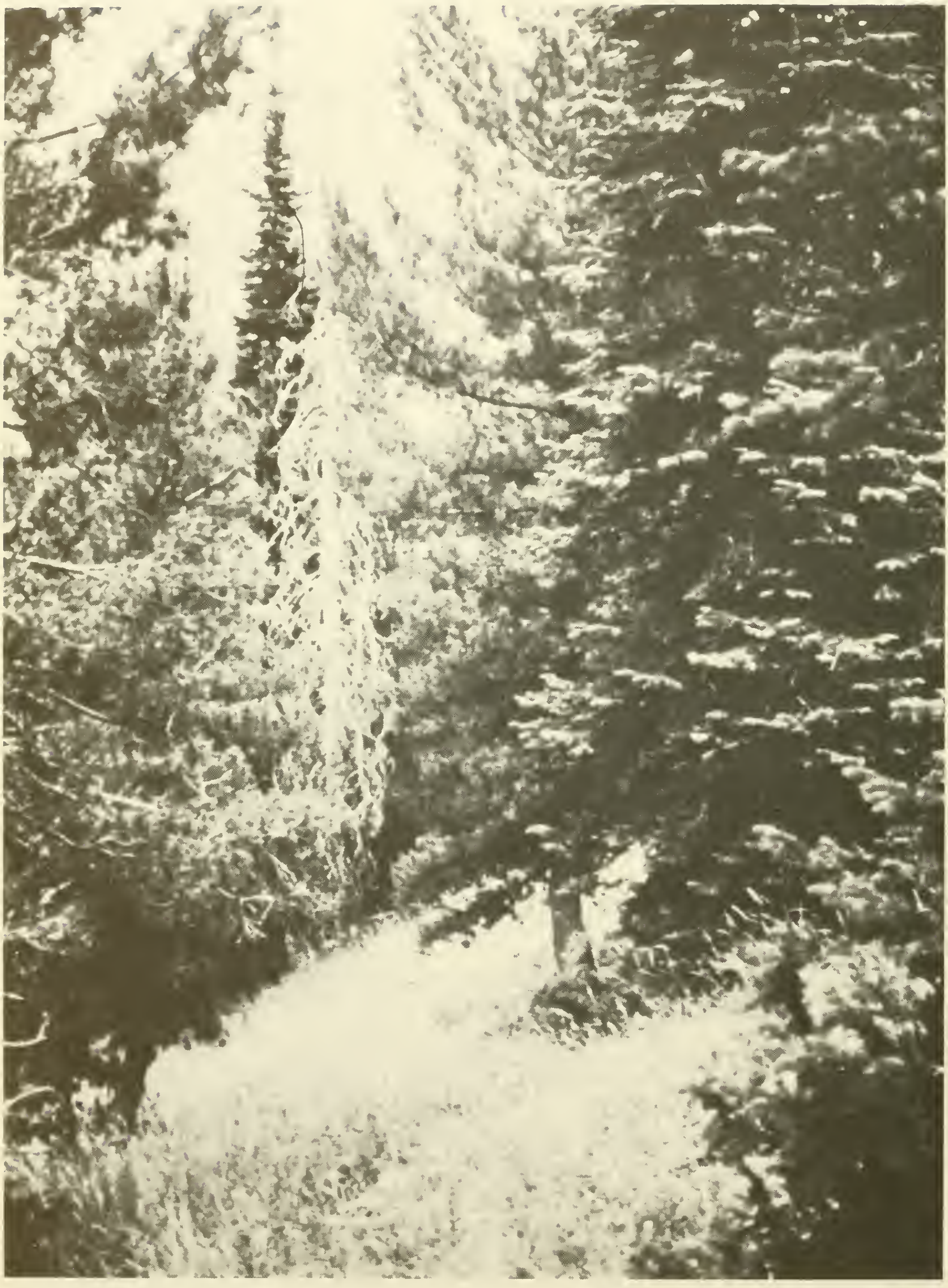


Fig. 3. Coniferous Forest Biome. Elko County: Snowslide Gulch, Jarbidge Mountains. Photograph by Gary Nigro.

chokecherry (*Prunus virginiana*), water birch (*Betula occidentalis*), willows, and cottonwoods.

Mountain Ants of Nevada

Because our tentative list of Nevada ants totals 180 species, the list (Table 1) of 50 montane species includes 28 percent of the fauna. But only 30 species are exclusively montane—17 percent of the total, 60 percent of the montane. All 50 montane species occur in the Coniferous Forest Biome. Nineteen of the montane species have been taken in the Ecotone. Five species which have been reported in the Coniferous Forest and in the Alpine have not been taken in the Ecotone, but it is reasonable to assume that they occur here; these would make a hypothetical Ecotone count of 24 species. No species is exclusively Ecotone. Fourteen species have been reported from the Alpine, none of which is exclusive to that biome.

We do not find the ant fauna to be in accord with Billings's subdivisions of the coniferous forests of Nevada. Only the Sierran is at all distinctive; six species occur in the Sierra Nevada which occur no where else in the state, and conversely there are seven species that do *not* occur in the Sierra, but are found in many other parts of the state. Most of our montane species are too widely distributed to show any pattern.

Montane species limited in Nevada to the Carson Range of the Sierra Nevada include *Manica bradleyi, Stenamma wheelerorum, Camptonotus essigi, Formica integroides, F. microphthalma,* and *F. sibylla.*

Montane species which have not been recorded in Nevada from the Carson Range include *Myrmica emeryana, M. lobifrons, Manica hunteri, Leptothorax crassipilis, Lasius vestitus, Formica hewitti,* and *F. subnuda.*

Table 1 shows that our montane ants are a relatively unspecialized lot. *Myrmica* comes first on everybody's list of Myrmicinae and *Manica* is second. *Stenamma* and *Aphaenogaster* are not far above them. But

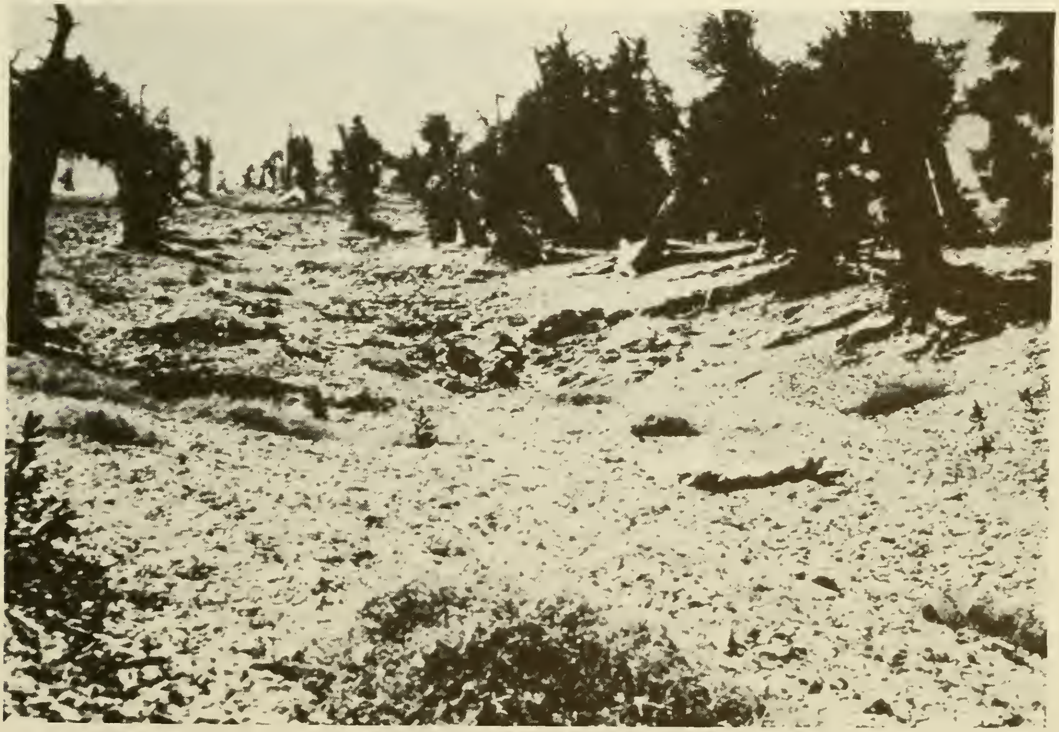


Fig. 4. Ecotone between Alpine and Coniferous Forest biomes. Open stand of bristlecone pines. Clark County: Charleston Peak, Spring Mountains. Photograph by Gary Nigro.

what is *Leptothorax* doing here? It is a moderately specialized myrmicine. *Tapinoma* is somewhat specialized, but it is one of the most versatile ants on earth—it deserves its own paragraph (see above). Among the Formicinae *Camponotus, Lasius* and *Formica* rate rather low on the scale of specialization in structure, but they rate much higher in behavior, *Formica* being perhaps the most plastic of all ant genera. *Polyergus* is, by contrast, highly specialized as an obligatory slave-maker. Apparently it can adapt to any environment in which it slaves (*Formica* spp.) can function, although we do not yet have it from the Alpine Biome.

The list is interesting not only for what it contains, but also for what it does not contain: the common genera in the lower biomes of Nevada: *Crematogaster, Monomorium, Solenopsis, Iridomyrmex*, and *Conomyrma*; all the harvesters (*Pogonomyrmex, Veromessor*, and *Pheidole*); and the honey ants (*Myrmecocystus*).

MOUNTAIN ANT NESTS IN NEVADA

Many of our records are based on stray workers only; for these we have no nest data. But those with nests are numerous enough to give a good picture of the nesting habits of Nevada mountain ants. In the following summary we have lumped together the data for all species.

TABLE 1. Mountain Ants of Nevada. A = Alpine; E = Ecotone; C = Coniferous Forest Biome; + = lower biomes (Pinyon-Juniper and/or Cool Desert). We have only one record of a mountain ant from the Hot Desert; even that was riparian.

				MYRMICINAE					
Myrmica					*Stenamma*				
americana		E	C	+	*diecki*			C	
brevinodis			C		*healthi*			C	
emeryana		E	C		*wheelerorum*			C	
fracticornis		E	C		*Aphaenogaster*				
lobifrons		E	C		*occidentalis*			C	+
tahoensis			C		*Leptothorax*				
sp. nov.	A		C		*crassipilis*			C	
Manica					*muscorum*	A	E	C	
bradleyi			C		*nevadensis*	A	E	C	+
hunteri		E	C		*nitens*			C	+
					rugatulus			C	+
				DOLICHODERINAE					
Liometopum					*Tapinoma*				
luctuosum			C	+	*sessile*	A	E	C	+
				FORMINCINAE					
Camponotus					*integroides*			C	
essigi			C		*lasioides*	A		C	+
laevigatus			C		*microphthalma*			C	
modoc			C		*neorufibarbis*	A	E	C	
vicinus			C	+	*nevadensis*			C	
Lasius					*obscuripes*	A		C	+
alienus	A	E	C		*obscuriventris*	A		C	+
flavus			C		*oreas*			C	+
neoniger			C	+	*planipilis*			C	
sitkaensis			C		*propinqua*			C	+
vestitus			C		*puberula*			C	
Formica					*sibylla*		E	C	
argentea	A		C	+	*subnuda*		E	C	
dakotensis	A	E	C	+	*subpolita*	A	E	C	+
densiventris		E	C	+	*subsericea*		E	C	+
fusca	A	E	C		*Polyergus*				
hewitti	A	E	C		*breviceps*		E	C	+

Coniferous Forest Biome: under a stone (mostly) or wood lying on the surface, or usually somewhat buried, 228; in rotten wood, 64; under earthen mounds constructed by the ants, 12; in soil with craters, 15; thatch mounds, 9; thatch and wood, 4.

Ecotone: Under a stone (mostly), or wood lying on the surface, or usually somewhat buried, 42; in rotten wood, 3; in soil with crater, 1.

Alpine: Under a stone lying on the surface or more commonly somewhat buried, 41; in soil with crater, 1; thatch mound, 1.

RECORDS FOR NEVADA MOUNTAIN ANTS

In the following list the arrangement of genera is that of Creighton (1950); for each genus, subgenus, or species-group, the species are arranged alphabetically. Under each species the county name is given first *in italics*; under each county the names of the ranges or mountains are followed by a dash; in each range (or mountain-group) are given the localities (peak or other topographic feature); finally the elevation of the record is given in feet above sea level. See Figure 5 for named localities.

Abbreviations and symbols: Co. = County; Hwy = Highway; mi = miles; Mt. = Mountain; Mts. = Mountains; nr = near; ' = feet. Compass directions are represented by the symbols E, N, S, W, and various combinations thereof. They are understood to be followed by the word *of*; e.g., "5 mi WSW Reno" would be read aloud as "five miles west-southwest of Reno."

When locality is given by legal description, the first figure is the section, the second is the township, and the third is the range. Because all Nevada ranges are east we have not so indicated, but township is cited as north or south; if the section is not known, we have given only township and range. Example: 23-7S-60, if fully expanded would read "section 23, Township 7 South, Range 60 East." The word *range* here has nothing to do with mountain ranges. (If the uninitiated reader is now thoroughly confused, we refer him to Wheeler and Wheeler 1963:76–77.)

Dr. Francoeur has made a preliminary examination of our material included under *Myrmica* spp. nov. He thinks we have at least four new species, which he will describe later. We have, therefore, added to each record our field number to make it possible to associate localities with the new names.

SUBFAMILY MYRMICINAE

Genus MYRMICA Latreille

Myrmica americana Weber

Clark Co.: Spring Mts.— Charleston Peak 10,400'. *Mineral Co.*: Wassuk Ra.— Grant Peak 8000'.

Myrmica brevinodis Emery

Washoe Co.: Carson Ra.— Little Valley 6400'; Hwy 27 nr Mt. Rose 8800'. *White Pine Co.*: Schell Creek Ra.— North Schell Peak 9700'.

Myrmica emeryana Forel

Clark Co.: Spring Mts.— Charleston Peak 10,400'. *White Pine Co.*: Schell Creek Ra.— South Schell Peak 9000'.

Myrmica fracticornis Emery

Clark Co.: Spring Mts.— Charleston Peak 8100', 9800'. *Elko Co.*: Jarbidge Mts.— 4 mi S Jarbidge 6600', 6700'. Ruby Mts.— Lamoille Canyon 8200'. *Esmeralda Co.*: White Mts.— Boundary Peak 9800'. *Humboldt Co.*: Pine Forest Ra.— Onion Reservoirs 8000'. *Nye Co.*: Grant Ra.— Troy Peak 10,800'. *Washoe Co.*: Carson Ra.— Little Valley 6400'; Whites Canyon on Mt. Rose 6800'; Tahoe Meadows on Mt. Rose 8400'. *White Pine Co.*: Snake Ra.— Mt. Moriah 10,000'; Mt. Washington 10,400'; Wheeler Peak 8300', 10,000', 10,400'.

Myrmica lobifrons Pergande

Elko Co.: Pilot Ra.— Pilot Peak 8800'. *Nye Co.*: Grant Ra.— Troy Peak 8400'. *White Pine Co.*: Schell Creek Ra.— North Schell Peak 9800', 10,000'.

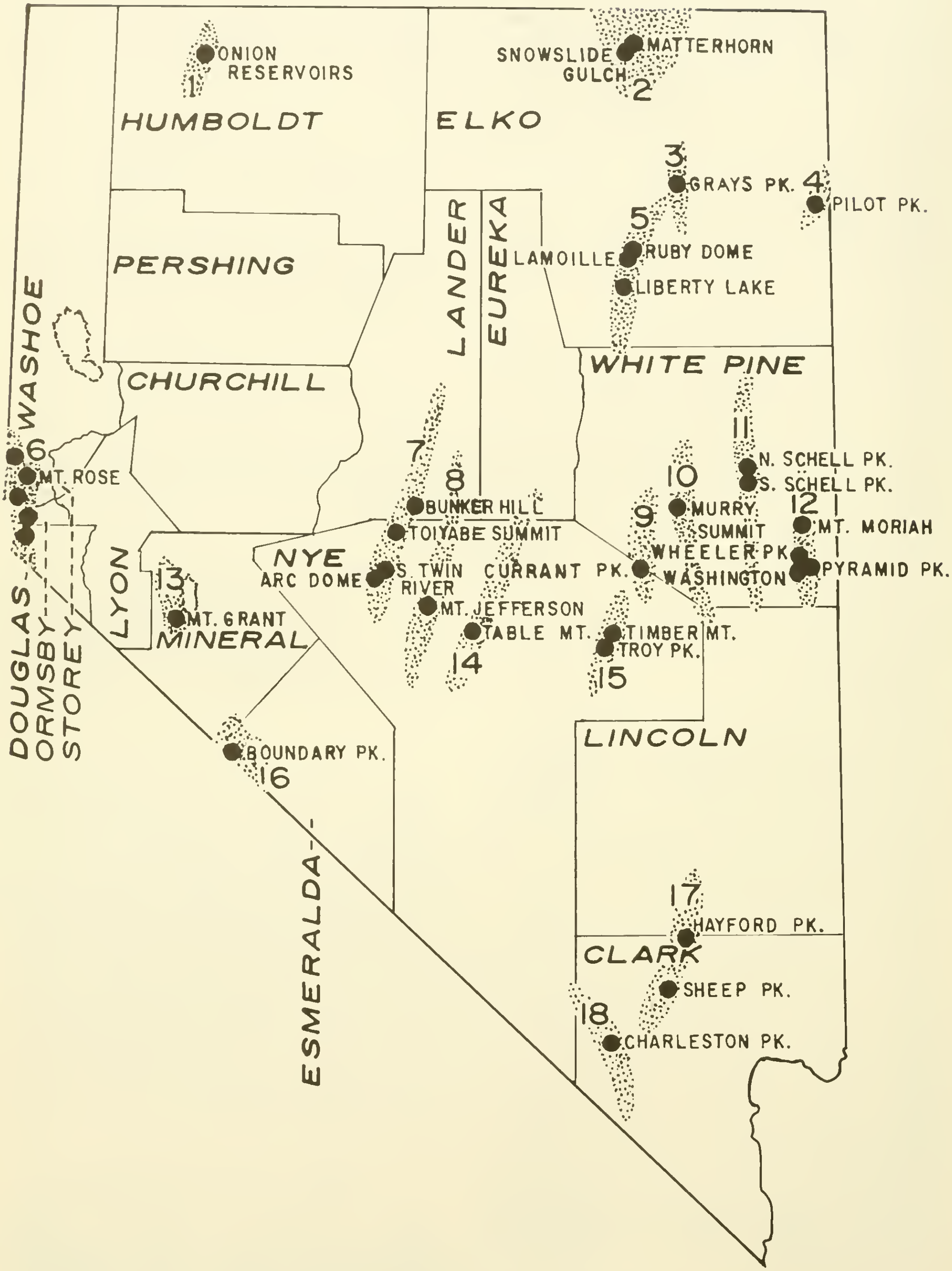

1
ONION RESERVOIRS
HUMBOLDT
SNOWSLIDE GULCH
MATTERHORN
2
ELKO
3
GRAYS PK.
4
PILOT PK.
5
LAMOILLE
RUBY DOME
LIBERTY LAKE
PERSHING
LANDER
EUREKA
WHITE PINE
CHURCHILL
WASHOE
6
MT. ROSE
7
8
BUNKER HILL
TOIYABE SUMMIT
11
N. SCHELL PK.
S. SCHELL PK.
10
MURRY SUMMIT
12
MT. MORIAH
9
WHEELER PK.
WASHINGTON
PYRAMID PK.
NYE
ARC DOME
S. TWIN RIVER
CURRANT PK.
13
MT. GRANT
MINERAL
LYON
MT. JEFFERSON
TABLE MT.
14
TIMBER MT.
TROY PK.
15
DOUGLAS
ORMSBY
STOREY
BOUNDARY PK.
16
LINCOLN
ESMERALDA
17
HAYFORD PK.
CLARK
SHEEP PK.
18
CHARLESTON PK.

Fig. 5. Nevada localities where mountain ant collections were made.

Myrmica tahoensis W. M. Wheeler

Clark Co.: Spring Mts.– Charleston Park 8100'. *Douglas Co.*: Carson Ra.– Spooner Summit 7100'. *Elko Co.*: East Humboldt Ra.– Angel Lake 8 mi SW Wells 7400, 8400'. Ruby Mts.– Lamoille Canyon 8200'. *Washoe Co.*: Carson Ra.– E side Lake Tahoe at Ormsby Co. line 6600'; between Mt. Rose and Lake Tahoe 8000'; Whites Canyon on Mt. Rose 6800'; Little Valley 6400'.

Myrmica spp. nov.

Elko Co.: Buck Creek Mts.– 9 mi WNW Jarbidge 6700' (#2352); Jarbidge Mts.– Snowslide Gulch 9000' (#5229). East Humboldt Ra.– Angel Lake 7 mi SW Wells 7400' (#2506). *Esmeralda Co.*: White Mts.– Boundary Peak 9000' (#5005, 5025). *Lander Co.*: Toiyabe Ra.– Bunker Hill 9200' (#5140). *Nye Co.*: Toiyabe Ra.– South Twin River 8600' (#5161), 8800' (#5162), 9100' (#5154). Toquima Ra.– Mt. Jefferson 9400' (#5164). *White Pine Co.*: Snake Ra.– Pyramid Peak 9800' (#5179), 10,600' (#5173), 10,800' (#5170); Mt. Washington 10,400' (#3104).

Genus Manica Jurine

Manica bradleyi (W. M. Wheeler)

Douglas Co.: Carson Ra.– 7 mi WNW Minden 7000'; Spooner Summer 7100'. *Ormsby Co.*: Carson Ra.– 7 mi WSW Carson City 7000'. *Washoe Co.*: Carson Ra.– Hobart Creek Reservoir 7200'; Hwy 27 nr Mt. Rose 8800'; Little Valley 6400'; Whites Canyon on Mt. Rose 6800'.

Manica hunteri (W. M. Wheeler)

Elko Co.: East Humboldt Ra.– Angel Lake (8 mi SW Wells) 9000'; Grays Peak 9600'. Ruby Mts.– Lamoille Canyon 7600', 7700', 8200'.

Genus Stenamma Westwood

Stenamma diecki Emery

Washoe Co.: Carson Ra.– Little Valley 6400'.

Stenamma heathi W. M. Wheeler

Washoe Co.: Carson Ra.– Lake Tahoe 6400'.

Stenamma smithi Cole

Ormsby Co.: Carson Ra.– 7 mi WSW Carson City 7000'.

Stenamma wheelerorum Snelling

Washoe Co.: Carson Ra.–Hwy 27 nr Mt. Rose 8800' TYPE NEST.

Genus Aphaenogaster Mayr

Aphaenogaster occidentalis Emery

Douglas Co.: Carson Ra.– 7 mi WNW Minden 7000'. *Elko Co.*: East Humboldt Ra.– 7 mi SW Wells 8400'. Ruby Mts.– Lamoille Canyon 7600'. *Ormsby Co.*: Carson Ra.– 5 mi WSW Carson City 6800'; 7 mi WSW Carson City 7000'. *Washoe Co.*: Carson Ra.– Franktown Road 5200'; Little Valley 6400', 6600', 7000'; Lower Price Lake 7000'; 6 mi SW Reno 6400'; Upper Price Lake 7200'; 3 mi N Verdi 6100'; 5 mi N Verdi 6900'; Peavine Peak 7400'; N end Lake Tahoe 6400'. *White Pine Co.*: Snake Ra.– Wheeler Peak 8000'.

Genus Leptothorax Mayr

Leptothorax crassipilis W. M. Wheeler

Clark Co.: Spring Mts.– Charleston Park 8100'.

Leptothorax muscorum (Nylander)

Douglas Co.: Pine Nut Mts.– 17 mi ESE Carson City (23-14N-22) 7600'. *Elko Co.*: Ruby Mts.– Lamoille Canyon 8200', 9700'. *Esmeralda Co.*: White Mts.– Boundary Peak 11,000. *Nye Co.*: Monitor Ra.– Table Mt. 10,000', 10,500', 10,800'. *Washoe Co.*: Carson Ra.– Little Valley 6400'; Hwy 27 nr Mt. Rose 8800'; California boundary 31-17N-18 8600'. *White Pine Co.*: Snake Ra.– Pyramid Peak 9800'; Wheeler Peak 7500'.

Leptothorax nevadensis W. M. Wheeler

Elko Co.: Ruby Mts.— Lamoille Canyon 7000'. *Nye Co.*: Toquima Ra.— S side Mt. Jefferson 10,000'. *Ormsby Co.*: Carson Ra.— 3 mi WSW Carson City 6100'. *Washoe Co.*: Carson Ra.— Little Valley 6400', 6500'; Hwy 27 nr Mt. Rose 8800'; 6 mi SW Reno 6400'; 10 mi WNW Reno 6500', 7000'.

Leptothorax nitens Emery

Washoe Co.: Carson Ra.— Little Valley 6400'; 4 mi N Verdi 6300'.

Leptothorax rugatulus Emery

Douglas Co.: Carson Ra.— 7 mi WNW Minden 6000', 7000'. *Elko Co.*: East Humboldt Ra.— 7 mi SW Wells 7400'. *Nye Co.*: Toquima Ra.— Mt. Jefferson 10,000. *Washoe Co.*: Carson Ra.— Little Valley 6400', 6800'; between Little Valley and Lake Tahoe 7800'; Whites Canyon on Mt. Rose 6800'; 6 mi SW Reno 6400'; 4 mi N Verdi 6300'.

Subfamily Dolichoderinae

Genus Liometopum Mayr

Liometopum luctuosum W. M. Wheeler

Clark Co.: Spring Mts.— Charleston Park 8100'. *Washoe Co.*: Carson Ra.— 16-16N-19 5200'; Little Valley 6500', 7100'; Whites Canyon on Mt. Rose 6800'; 6 mi SW Reno 6400'.

Genus Tapinoma Foerster

Tapinoma sessile (Say)

Clark Co.: Spring Mts.— 4 mi NNE Charleston Park 7700'. Sheep Ra.— Hayford Peak 9700', 9900'; Sheep Peak 9700'. *Douglas Co.*: Carson Ra.— Spooner Summit 7100'. *Elko Co.*: Ruby Mts.— Lamoille Canyon 8200'. Jarbidge Mts.— Pine Creek (-46N-58) 6500'. *Esmeralda Co.*: White Mts.— Boundary Peak 8800', 9000', 11,320'. *Humboldt Co.*: Pine Forest Ra.— Onion Reservoirs 8000'. *Lander Co.*: Toiyabe Ra.— Bunker Hill 7900'. *Nye Co.*: Grant Ra.— Troy Peak 9400'. Toiyabe Ra.— South Twin River (-11N-42) 9200'. *Ormsby Co.*: Carson Ra.— 5 mi WSW Carson City 6800'. *Washoe Co.*: Carson Ra.— Little Valley 6400'; Hobart Creek Reservoir 7200'; Lower Price Lake 7000'; 3 mi N Verdi 6100'; 4 mi N Verdi 6300'; 7 mi W Reno; 10 mi NW Reno 6300'; E side Lake Tahoe at Ormsby Co. line 6600'; N end Lake Tahoe at California boundary 8600'. *White Pine Co.*: Egan Ra.— nr Murry Summit 8500', 9200', 9300'. Snake Ra.— Wheeler Peak 8300', 9100', 10,500'.

Subfamily Formicinae

Genus Camponotus Mayr

Subgenus Camponotus Mayr

Camponotus laevigatus (F. Smith)

Clark Co.: Spring Mts.— Charleston Park 8100'. *Douglas Co.*: Carson Ra.— E side Lake Tahoe 2 mi S Glenbrook 6400'. *Washoe Co.*: Carson Ra.— California boundary 31-17N-18 8600'.

Camponotus modoc W. M. Wheeler

Clark Co.: Sheep Ra.— peak 1½ mi NE Hayford Peak 9800'. Springs Mts.— Charleston Peak 7700', 8400', 9700'. *Douglas Co.*: Carson Ra.— Spooner Summit 7100'; E side Lake Tahoe 2 mi S Glenbrook 6400'. *Elko Co.*: East Humboldt Ra.— Grays Peak (-36N-61) 9600'; 7 mi SW Wells 7400'. Ruby Mts.— Ruby Dome 10,500'; Thomas Canyon off Lamoille Canyon 7700'; Liberty Pass (-32N-58) 10,000', 10,300'. Jarbidge Mts.— Snowslide Gulch (-46N-58) 9000'. Pilot Ra.— Pilot Peak 8500', 10,000'. *Humboldt Co.*: Pine Forest Ra.— Onion Reservoirs 8000'. *Lander Co.*: Toiyabe Ra.— Bunker Hill 9300', 9400'. *Nye Co.*: Grant Ra.— Troy Peak 7900', 8900', 9400', 9900', 10,900'. Toiyabe Ra.— South Twin River 9100'. *Washoe Co.*: Carson Ra.— Little Valley 6400'; between Little Valley and Lake Tahoe (24-16N-18) 7800'; Fuller Lake 3 mi S Verdi 6000''; Hwy 27 nr Mr. Rose 8800'; Tahoe Meadows on Mt. Rose 8400'; California boundary 31-17N-18 8600'. *White Pine Co.*: Egan Ra.— nr Murry Summit 9000', 9200'. Schell Creek Ra.— South Schell Peak 8500', 8600', 8800', 9700'; North Schell Peak 9500', 9700', 9800'. Snake Ra.— Mt. Moriah 10,400'; Wheeler Peak 9700', 10,000', 10,700', 12,000'; Pyramid Peak 10,000', 10,500', 10,600'.

Subgenus Myrmentoma Forel

Camponotus essigi M. R. Smith

Washoe Co.: Carson Ra.– Little Valley 6600'; Fuller Lake 3 mi S Verdi 6000'; between Little Valley and Lake Tahoe 7800'.

Subgenus Tanaemyrmex Ashmead

Camponotus vicinus Mayr

Clark Co.: Spring Mts.– Charleston Park 8100'; 16 mi NE Pahrump (-18S-55) 8000'. Sheep Ra.– Sheep Peak 9700'. *Douglas Co.*: Carson Ra.– 6 mi WNW Minden 6000'. *Elko Co.*: Ruby Mts.– Lamoille Canyon 7700'. Jarbidge Mts.– Snowslide Gulch (-46N-58) 8000'. *Esmeralda Co.*: White Mts.– Boundary Peak 9000'. *Nye Co.*: Grant Ra.– Troy Peak 9100'. *Washoe Co.*: Carson Ra.– Little Valley 6200', 6400', 6500', 6600'; Lower Price Lake 7000'; between Little Valley and Lake Tahoe 7600', 7800'; Fuller Lake 3 mi S Verdi 6000'; E side Lake Tahoe at Ormsby Co. line 6600'; Hwy 27 nr Mt. Rose 8800'; Whites Canyon on Mt. Rose 6800'; 6 mi SW Reno 6400'.

Genus Lasius Fabricius

Subgenus Lasius Fabricius

Lasius alienus (Foerster)

Clark Co.: Spring Mts.– Charleston Park 8100'; Charleston Peak 8300'; 16 mi NE Pahrump 8000'; Camp Bonanza 7500'. *Douglas Co.*: E side Lake Tahoe 2 mi S Glenbrook 6400'. *Elko Co.*: East Humboldt Ra.– Grays Peak (-36N-61) 8900', 9600'; 8 mi SW Wells 8400'. Ruby Mts.– Lamoille Canyon 7700', 8200', 8800', 8900'; Thomas Canyon off Lamoille Canyon 7600', 7700'; Lamoille Creek 8900'; Lamoille Lake 9700'. *Humboldt Co.*: Pine Forest Ra.– Onion Reservoirs 8000'. *Lander Co.*: Toiyabe Ra.– Bunker Hill 8900'. *Nye Co.*: Toiyabe Ra.– South Twin River (-11N-42) 8800'. *Washoe Co.*: Carson Ra.– Little Valley 6400'; Whites Canyon on Mt. Rose 6800'.

Lasius neoniger Emery

Clark Co.: Spring Mts.– Charleston Peak 8300'. *Elko Co.*: Ruby Mts.– Thomas Canyon off Lamoille Canyon 7600'. *Nye Co.*: Toiyabe Ra.– South Twin River (-11N-42) 9000'.

Lasius sitkaensis Pergande

Clark Co.: Spring Mts.– Charleston Park 8100'. Sheep Ra.– 2 mi N Sheep Peak 9000'. *Douglas Co.*: Carson Ra.– Kingsbury Grade 6 mi WNW Minden; E side Lake Tahoe 2 mi S Glenbrook 6400'. *Elko Co.*: Ruby Mts.– Lamoille Canyon 7600', 7700'. Jarbidge Mts.– Matterhorn 8500'. *Humboldt Co.*: Pine Forest Ra.– Onion Reservoirs 8000'. *Washoe Co.*: Carson Ra.– Little Valley 6200', 6400', 6600', 7000'; Fuller Lake 3 mi S Verdi 6000'; California boundary 31-17N-18 8600'. *White Pine Co.*: Egan Ra.– nr Murry Summit 9100'. Schell Creek Ra.– South Schell Peak 8800'. Snake Ra.– Wheeler Peak 9700'.

Subgenus Cautolasius Wilson

Lasius flavus (Fabricius)

Douglas Co.: Carson Ra.– Glenbrook 6200'. *Nye Co.*: Toiyabe Ra.– South Twin River (-11N-42) 9100'. *Washoe Co.*: Carson Ra.– Little Valley 6400'; Hwy 27 nr Mt. Rose 8800'; Lower Price Lake 7000'; Upper Price Lake 7200'; E side Lake Tahoe at Ormsby Co. line 6600'; Mt. Rose 10,000', 10,300', 10,400'. *White Pine Co.*: Snake Ra.– Mt. Moriah 10,000'. Egan Ra.– nr Murry Summit 9200'.

Subgenus Chthonolasius Ruzsky

Lasius vestitus W. M. Wheeler

Clark Co.: Spring Mts.– Charleston Peak 7700', 8100'. *Elko Co.*: Ruby Mts.– Lamoille Canyon 7600'.

Genus Formica Linnaeus

The *neogagates* species-group

Formica lasioides Emery

Clark Co.: Spring Mts.– Charleston Park 8100'; Charleston Peak 8300'; Camp Bonanza 7500'. *Elko Co.*: Jarbidge Mts.– Jarbidge 6200'. East Humboldt Ra.– 7 mi SW Wells 7400'. *Humboldt Co.*: Pine Forest Ra.– Onion Reservoirs 8000'. *Mineral Co.*:

Wassuk Ra.— -8N-28 8000'. *Nye Co.*: Monitor Ra.— Table Mt. 10,500', 10,600', 10,800', 10,900'. *Washoe Co.*: Carson Ra.— Little Valley 6400', 7000', 7500'; Hwy 27 nr Mt. Rose 8800'; Mt. Rose 10,200', 10,400', 10,500'; Whites Canyon on Mt. Rose (-18N-19) 6800'; 6 mi SW Reno 6400'; 4 mi N Verdi 6300'. *White Pine Co.*: Schell Creek Ra.— South Schell Peak 8900'. Snake Ra.— Mt. Moriah 10,500'; Mt. Washington 10,400'.

The *rufa* species-group

Formica dakotensis Emery

Nye Co.: Monitor Ra.— Table Mt. (E side) 10,800'. *Washoe Co.*: Carson Ra.— Mt. Rose (15-17N-18), 10,500'. *White Pine Co.*: Snake Ra.— Wheeler Peak 10,000', 10,500'.

Formica densiventris Viereck

Elko Co.: Ruby Mts.— base of Ruby Dome 7200'. *Esmeralda Co.*: White Mts.— Boundary Peak 8900'. *Humboldt Co.*: Pine Forest Ra.— Onion Reservoirs 8000'. *Nye Co.*: Toquima Ra.— ridge S of Mt. Jefferson 10,000'. *Washoe Co.*: Carson Ra.— between Little Valley and Lake Tahoe 7800'; Hwy 27 nr Mt. Rose 8800'.

Formica integroides W. M. Wheeler

Washoe Co.: Carson Ra.— 10 mi W Reno 6500', 7000'; 6 mi SW Reno 6400'; 4 mi N Verdi 6300'.

Formica nevadensis W. M. Wheeler

Esmeralda Co.: White Mts.— Boundary Peak 9000'. *Washoe Co.*: Carson Ra.— Whites Canyon on Mt. Rose 6800'; "Lake Tahoe." *White Pine Co.*: Schell Creek Ra.— North Schell Peak 10,400'.

Formica obscuripes Forel

Elko Co.: Ruby Mts.— Thomas Canyon off Lamoille Canyon 7700'. *Nye Co.*: Toquima Ra.— S side Mt. Jefferson 10,500'. *Washoe Co.*: Carson Ra.— Little Valley 6400', 6500'; Marlette Lake 8000'. *White Pine Co.*: Egan Ra.— 10 mi SW Ely (-14N-62) 10,000'; nr Murry Summit 8600', 8800'.

Formica obscuriventris Mayr

Humboldt Co.: Pine Forest Ra.— Onion Reservoirs 8000'. *Washoe Co.*: Carson Ra.— 4 mi N Verdi 6300'; Tahoe Meadows on Mt. Rose 8400'. *White Pine Co.*: Egan Ra.— 10 mi SSW Ely 10,000'.

Formica oreas W. M. Wheeler

Elko Co.: Ruby Mts.— end of Lamoille Canyon road 8800'. *Washoe Co.*: Carson Ra.— Little Valley 6400'; Hobart Creek Reservoir 7200'.

Formica planipilis Creighton

Elko Co.: Ruby Mts.— Lamoille Canyon 8800'; Lee Lake on Lee Peak 9700'. Jarbidge Mts.— Snowslide Gulch 8000'. *Washoe Co.*: Carson Ra.— Fuller Lake (32-14N-18) 6000'. *White Pine Co.*: Schell Creek Ra.— 1 mi W North Schell Peak 10,200; Berry Creek on South Schell Peak 8800'. Snake Ra.— NE slope Wheeler Peak 8300'.

Formica propinqua W. M. Wheeler

Washoe Co.: Carson Ra.— Little Valley 6400'; Lower Price Lake 7000'; between Little Valley and Lake Tahoe 7600', 7800'; Hobart Creek Reservoir 7200'; 5 mi SW Reno 5600'.

The *fusca* species-group

Formica argentea W. M. Wheeler

Clark Co.: Springs Mts.— Charleston Peak 8100', 8300', 8400', 9700', 10,300', 10,400'; Mummy Mt. 10,800', 11,500'. Sheep Ra.— Hayford Peak 9700'. *Elko Co.*: Jarbidge Mts.— Jarbidge 6200'. Ruby Mts.— Lamoille Creek 8800'. *Esmeralda Co.*: White Mts.— ridge 2½ mi NE Boundary Peak 10,800'. *Mineral Co.*: Wassuk Ra.— -8N-28 8000'. *Nye Co.*: Grant Ra.— ridge between Timber Mt. and Troy Peak 10,000'; Troy Peak 7400', 7900'. Toiyabe Ra.— South Twin River 9100'. Toquima Ra.— Mt. Jefferson

10,000'. *Ormsby Co.*: Carson Ra.— 5 mi WSW Carson City 6800'. *Washoe Co.*: Carson Ra.— Marlette Lake 8000'; Little Valley 6400'; between Little Valley and Lake Tahoe 7600'. *White Pine Co.*: Schell Creek Ra.— North Schell Peak 9700'; South Schell Peak 8800'. Snake Ra.— Wheeler Peak 9700'; Pyramid Peak 9200', 9400'.

Formica fusca Linnaeus

Douglas Co.: Carson Ra.— Kingsbury Grade 7000'; Spooner Summit 7100'. *Elko Co.*: Ruby Mts.— Lee Peak 11,000'; Ruby Dome 10,500', 11,000'; Thomas Canyon off Lamoille Canyon 7700'; Lamoille Lake 9700'; nr Liberty Lake 10,000'; Liberty Lake 10,300'; Liberty Pass 10,400'. Jarbidge Mts.— Matterhorn 10,200', 10,300'; Snowslide Gulch 9200'. East Humboldt Ra.— Grays Peak 9900'. Pilot Ra.— Pilot Peak 8500'. *Esmeralda Co.*: White Mts.— 2½ mi NE Boundary Peak 10,800'; Boundary Peak 10,500'. *Humboldt Co.*: Pine Forest Ra.— Onion Reservoirs 8000'. *Lander Co.*: Toiyabe Ra.— Bunker Hill 9300', 9700', 10,200'. *Mineral Co.*: Wassuk Ra.— Mt. Grant 10,200'. *Nye Co.*: Grant Ra.— Troy Peak 9900', 10,100', 10,800', 10,900, 11,200'; Timber Mt. 10,200', 10,400'. Toiyabe Ra.— Toiyabe Dome 10,100', 10,500'; between Arc Dome and Toiyabe Dome 9800'; South Twin River 9000'. *Ormsby Co.*: Carson Ra.— 3 mi WSW Carson City 6100'. *Washoe Co.*: Carson Ra.— Little Valley 6400', 6500', 6600'; Hobart Creek Reservoir 7200'; between Little Valley and Lake Tahoe 7800'; Marlette Lake 8000'; Hwy 27 nr Mt. Rose 8800', 9100'; Lower Price Lake 7000'; Mt. Rose 10,000', 10,200', 10,300', 10,500', summit (10,778'); Whites Canyon on Mt. Rose 6800'. *White Pine Co.*: White Pine Mts.— Currant Mt. 10,700', 10,800', 11,200'. Snake Ra.— Wheeler Peak 10,000', 10,500', 10,700', 10,800', 11,100'; Mt. Moriah 10,400', 10,500', 10,800', 11,400', 11,500'; Pyramid Peak 10,500', 10,800'. Schell Creek Ra.— North Schell Peak 10,300', 10,400', 10,500'; South Schell Peak 9700'.

Formica hewitti W. M. Wheeler

Elko Co.: Buck Creek Mts.— 9 mi NW Jarbidge 6700'. *Esmeralda Co.*: White Mts.— N slope of peak N of Boundary Peak 11,600'; Boundary Peak 11,000'. *Mineral Co.*: Wassuk Ra.— Mt. Grant 11,000'. *White Pine Co.*: Snake Ra.— Wheeler Peak 10,100'; Pyramid Peak 9800'.

Formica microphthalma Francoeur

Douglas Co.: Carson Ra.— Kingsbury Grade 7000'. *Washoe Co.*: Carson Ra.— between Little Valley and Lake Tahoe 7600'; Hwy 27 nr Mt. Rose 8800'.

Formica neorufibarbis Emery

Clark Co.: Sheep Ra.— Hayford Peak 9800'. *Douglas Co.*: Carson Ra.— Spooner Summit 7100'. *Elko Co.*: Ruby Mts.— end of Lamoille Canyon road 8800'; Lamoille Creek 9200'. East Humboldt Ra.— Angel Lake 8400'; Grays Peak (-36N-61) 10,500'. Jarbidge Mts.— Jarbidge 6200'. Buck Creek Mts.— 9 mi WNW Jarbidge 6700'. *Esmeralda Co.*: White Mts.— Boundary Peak 11,000', 11,600', 12,000', 12,200'. *Humboldt Co.*: Pine Forest Ra.— Onion Reservoirs 8000'. *Mineral Co.*: Wassuk Ra.— Mt. Grant 11,000'. *Nye Co.*: Toquima Ra.— Mt. Jefferson 11,700', 11,800', 11,900'. Toiyabe Ra.— Arc Dome 11,200', 11,500', 11,600', 11,700', summit (11,775'). *Washoe Co.*: Carson Ra.— Little Valley 6400'; Hobart Creek Reservoir 7200'; Hwy 27 nr Mt. Rose 8700', 8800'; Tahoe Meadows on Mt. Rose 8400'; Mt. Rose 10,400', 10,500', 10,700', summit (10,778'). *White Pine Co.*: Snake Ra.— Mt. Moriah 11,000', 11,100'; Wheeler Peak 9700'. Schell Creek Ra.— North Schell Peak 9000', 10,500'; South Schell Peak 8600', 8800', 9900'.

Formica sibylla W. M. Wheeler

Douglas Co.: Carson Ra.— 6 mi WNW Minden 6000'. *Ormsby Co.*: Carson Ra.— 5 mi SW Carson City 7100'; 7 mi WSW Carson City 7000'. *Washoe Co.*: Carson Ra.— Little Valley 6400', 6800', 6900', 7000', 7500'; Hwy 27 nr Mt. Rose 9000'; Mt. Rose 10,500'; Whites Canyon on Mt. Rose 6800'; 6 mi SW Reno 6400'; Sand Point E side Lake Tahoe 6400'; Marlette Lake 8000'; Lower Price Lake 7000'.

Formica subpolita Mayr

Clark Co.: Sheep Ra.— Hayford Peak 9700', 9900'; Sheep Peak 9000', 9700'. *Esmeralda Co.*: White Mts.— Boundary Peak 10,800'. *Humboldt Co.*: Pine Forest Ra.— Onion Reservoirs 8000'. *Mineral Co.*: Wassuk Ra.— Mt. Grant 10,200'. *Nye Co.*: Toiyabe Ra.— Arc Dome 9200'; South Twin River 8800', 9100', 9200'. Toquima Ra.— Mt. Jefferson 9400', 9500', 10,000'. *Washoe Co.*: Carson Ra.— Fuller Lake (3 mi S Verdi) 6000'; 6 mi SW Reno 6400'; 10 mi WNW Reno 6500', 7000'.

Formica subsericea Say

Clark Co.: Spring Mts.— Charleston Peak 10,400', 11,000'; Mummy Mt. 11,500'. Sheep Ra.— Hayford Peak 9700'. *Elko Co.*: Ruby Mts.— end of Lamoille Canyon road 8800'; Lamoille Canyon 7600'; Thomas Canyon off Lamoille Canyon 7700'. East Humboldt Ra.— Angel Lake 8400'; Grays Peak 9000'. *Humboldt Co.*: Pine Forest Ra.— Onion Reservoirs 8000'. *Nye Co.*: Grant Ra.— Troy Peak 8800', 9000', 10,700'. Monitor Ra.— Table Mt. 9500'. Toiyabe Ra.— South Twin River 8800'. *Ormsby Co.*: Carson Ra.— 7 mi WSW Carson City 7000'. *Washoe Co.*: Carson Ra.— Hwy 27 nr Mt. Rose 8800'; Mt. Rose 10,300', 10,500'. *White Pine Co.*: Snake Ra.— Mt. Washington 9500'; Wheeler Peak 7500', 8000'. Egan Ra.— nr Murry Summit 9200'.

The *sanguinea* species-group

Formica puberula Emery

Elko Co.: Ruby Mts.— Thomas Canyon off Lamoille Canyon 7600'; Lamoille Canyon 8200'. *Washoe Co.*: Carson Ra.— Little Valley 6400'.

Formica subnuda Emery

Elko Co.: East Humboldt Ra.— 8 mi SW Wells 8400'; Grays Peak 9000'. Ruby Mts.— Ruby Dome 10,500'; Lamoille Canyon 8200'; Liberty Pass 10,300'. *White Pine Co.*: Snake Ra.— Wheeler Peak 10,000', 10,500'; saddle between Mt. Washington and Lincoln Peak 11,000'; Mt. Washington 10,400'; Pyramid Peak 9900', 10,500', 10,600'. Schell Creek Ra.— North Schell Peak 9900', 10,600

Genus Polyergus Latreille

Polyergus breviceps Emery

Elko Co.: Ruby Mts.— Ruby Dome 10,500'. *Nye Co.*: Grant Ra.— Troy Peak 7400'. *Washoe Co.*: Carson Ra.— Little Valley 6400', 6500'; Hwy 27 nr Mt. Rose 8800', 9100'; 6 mi SW Reno 6400'.

Literature Cited

Billings, W. D. 1954. Nevada trees. Agric. Exten. Ser. Univ. Nevada Bull. 94: 1–125.

Creighton, W. S. 1950. The ants of North America. Bull. Mus. Comp. Zool., Harvard Coll. 104: 1–585, 57 pl.

Gregg, R. E. 1963. The ants of Colorado. Univ. Colorado Press, Boulder. 792 p.

Mani, M. S. 1968. Ecology and biogeography of high altitude insects. W. Junk, The Hague. 530 p.

Smith, M. R. 1928. The biology of *Tapinoma sessile* Say, an important house-infesting ant. Ann. Entomol. Soc. Amer. 21:307–330.

Van Pelt, A. 1963. High altitude ants of the southern Blue Ridge. Amer. Midland Natur. 69:205–223.

Weber, N. A. 1943. The ants of the Imatong Mountains, Anglo-Egyptian Sudan. Bull. Mus. Comp. Zool., Harvard College 93:263–289, 16 pl.

Wheeler, G. C., and Jeanette Wheeler. 1963. The ants of North Dakota. Univ. North Dakota Press. Grand Forks. 326 p.

______. 1973. Ants of Deep Canyon. Philip L. Boyd Deep Canyon Desert Research Center, Univ. California, Riverside. 162 p.

Wheeler, W. M. 1917. The mountain ants of western North America. Proc. Amer. Acad. Arts Sci. 52:457–469.

NEW SYNONYMY AND NEW SPECIES OF AMERICAN BARK BEETLES (COLEOPTERA: SCOLYTIDAE), PART VII[1]

Stephen L. Wood[2]

Abstract.— New synonymy of American Scolytidae is proposed as follows: *Coccotrypes cyperi* (Beeson) (= *Thamnurgides indicus* Eggers), *Pityophthorus attenuatus* Blackman (= *Pityophthorus pusillus* Wood), *Pityophthorus digestus* LeConte (= *Pityophthorus aplanatus* Schedl), *Pseudohylesinus sericeus* (Mannerheim) (= *Pseudohylesinus yasamatsui* Nobuchi), *Xyleborus mutabilis* Schedl (= *Xyleborus meridensis* Wood). New names are proposed to replace junior homonyms as follows: *Pityophthorus indigus* for *Pityophthorus indigens* Wood, 1977 (nec Wood 1976), and *Xyloborus devexulus* for *Xyleborus devexus* Wood, 1977 (nec Schedl, 1977). The following species are named as new to science: *Conophthorus echinatae* (Missouri), *Lymantor alaskanus* (Alaska), *Pityophthorus delicatus* (Mexico), *P. rubidus* (Arizona and Mexico), *P. vesculus* (Panama), *Scolytodes comitabilis, S. crinalis, S. crinitus, S. decorus, S. genialis, S. habilis, S. libidus, S. perpussilus, S. semipunctatus* (Venezuela).

On the following pages some newly discovered cases of synonymy are reported, two new names are proposed to replace junior homonyms, and 14 species are named as new to science. The species new to science represent *Conophthorus* (1), *Lymantor* (1), *Pityophthorus* (3), and *Scolytodes* (9), and were taken in the United States (2), Mexico (1), Panama (1), Venezuela (9), and both USA and Mexico (1).

Coccotrypes cyperi (Beeson)

Thamnurgides cyperi Beeson, 1929, Insects of Samoa, Coleoptera 4(4):230 (Holotype, female; Apia, Samoan Islands, British Mus. Nat. Hist.)

Thamnurgides indicus Eggers, 1936, Ann. Mag. Nat. Hist. (10)17:631 (Holotype, female; Sakalaspur, Mysore, India; British Mus. Nat. Hist). *New Synonymy*

Two topotypic paratypes of *Thamnurgides cyperi* Beeson were compared directly to my series from Central America and Puerto Rico, part of which had previously been compared to the holotype of *Thamnurgides indicus* Eggers. While occasional specimens are more sparsely asperate on the pronotal disc, as reported by Beeson (1939, Indian For. Rec. 5:294), for *indicus*, most of the specimens are as in his type series of *cyperi*. Since only one species is represented by this material, the name *indicus* must be placed in synonymy. New localities where this species has been taken include: Keeau, Hawaii, Hawaiian Islands, IV-1978, in *Myrica*; Mataeia, Tahiti Islands, 16-IV-1977.

Pityophthorus attenuatus Blackman

Pityophthorus attenuatus Blackman, 1942, Proc. U. S. Nat. Mus. 92:222 (Holotype, female; Mexico; U. S. Nat. Mus.)

Pityophthorus pusillus Wood, 1964, Great Basin Nat. 24:62 (Holotype, female; 9 miles or 14 km S Zimapan, Hidalgo, Mexico; Wood Coll.). *New synonymy*

The type series of *attenuatus* Blackman and *pusillus* Wood and 113 other specimens from the states of Jalisco and Hidalgo (Mexico) and from Guatemala were examined. While most other characters are constant, there is considerable variation in the length and distribution of the female frontal vestiture. In view of this variation, it appears advisable to place the new *pusillus* in synonymy. Some specimens approach *subsimilis* Schedl so closely that a further review of this complex may be necessary when more material is available for study. At the present time, the host of *subsimilis* (*Pinus*) gives adequate reason for maintaining this as a separate species.

---

[1] Part of the research was sponsored by the National Science Foundation.

[2] Life Science Museum and Department of Zoology, Brigham Young University, Provo, Utah 84602. Scolytidae contribution No. 67.

Pityophthorus digestus (LeConte)

Pityophthorus digestus LeConte, 1874, Trans. Amer. Ent. Soc. 5:71 (Lectotype, sex?; Mojave Desert, California; Mus. Comp. Zool., designated by Bright, 1976, Coleopt. Bull. 30:185)

Pityophthorus aplanatus Schedl, 1930, Canadian Ent. 62:195 (Holotype, female; Athabasca Falls, Alberta; Canadian Nat. Coll.). *New synonymy*

The type series of *Pityophthorus aplanatus* Schedl differs rather significantly from the lectotype and other specimens of *digestus* LeConte from southern California. However, a long series from eastern Wyoming is clearly intermediate and includes specimens almost indistinguishable from Schedl's type. An apparent character cline extends from Alberta to New Mexico. In view of the intergradation, it is necessary to place the junior name, *aplanatus*, in synonymy.

Pityophthorus indigus Wood, new name

Pityophthorus indigens Wood, 1977 (nec Wood, 1976), Great Basin Nat. 37:214 (Holotype, female; Guild, Colorado; Wood Coll.)

While the name *Pityophthorus indigens* Wood (1976, Great Basin Nat. 36:361) was in press, I inadvertently used the same name, cited above, for another species. The new name *Pityophthorus indigus* is proposed to replace the junior homonymy *indigens* Wood, 1977.

Pseudohylesinus sericeus (Mannerheim)

Hylurgus sericeus Mannerheim, 1843, Moskov. Obshch. Isp. Prirody, Otd. Biol. Buil. (Bull. Soc. Imp. Moscow) 16(2):296 (Holotype, female; Sitka, Alaska; Univ. Zool. Mus., Helsinki)

Pseudohylesinus yasamatsui Nobuchi, 1971, Bull. Gov. For. Expt. Sta., Tokyo 238:160 (Holotype, male; Takanishi, Nagano, Japan; Gov. For. Expt. Sta., Tokyo). *New synonymy*

Two paratypes of *Pseudohylesinus yasamatsui* Nobuchi in the Canadian National Collection were compared directly to my homotypes of *sericeus* (Mannerheim) and to other material in the Canadian National Collection. Only one species is represented by this material. It is, therefore, necessary to place the junior name in synonymy.

The introduction of this species into Japan marks the first record of this genus outside western North America.

Xyloborus devexulus, new name

Xyleborus devexus Wood, 1977 (Dec.) (nec. Schedl 1977), Great Basin Nat. 37(2):219 (Holotype, female; Homestead, Florida; Wood Coll.)

The name *Xyleborus devexus* (Zeitschr. Österr. Ent. 29, part 1/2, Nov. 1977) was used by Schedl in the same month that I published the same name as cited above. Because Schedl's name was in print a few weeks earlier his name has priority. The new name *devexulus* is proposed as a replacement for *Xyleborus devexus* Wood.

Xyleborus mutabilis Schedl

Xyleborus mutabilis Schedl, 1935, Arch. Inst. Biol. Veg. Río de Janeiro 2:92 (Holotype, female; Venezuela; Schedl Coll.)

Xyleborus meridensis Wood, 1971, Brigham Young Univ. Sci. Bull., Biol. Ser. 19(1):38 (Holotype, female; La Carbonera Erpeximental Forest, Merida, Venezuela; Wood Coll.). *New synonymy*

The female holotypes of *Xyleborus mutabilis* Schedl and *meridensis* Wood were compared directly to one another and to other material in my collection. Since only one species is represented, the junior name *meridensis* must be placed in synonymy.

TAXA NEW TO SCIENCE

Conopthorus echinatae, sp. n.

This species is distinguished from *coniperda* (Schwarz) by the smaller size, by the more slender form, by the more strongly arched elytral declivity, by the coarser pronatal and elytral punctures, and by the weaker transverse frontal impression.

Female.— Length 2.4 mm, 2.5 times as long as wide; color very dark brown.

Frons as in *coniperda* except transverse impression between epistoma and upper level of eyes not as deep.

Pronotum as in *coniperda* except punctures on disc and near base larger their lateral margins almost never bearing a granule.

Elytra as in *coniperda* except punctures larger, interstriae two and one-half to three times as wide as striae, declivital sulcus narrower and less strongly impressed, vestiture averaging slightly longer.

MALE.— Similar to female except lower half of frons with a distinct, median, subcarinate summit.

TYPE LOCALITY.— Winona, Missouri.

TYPE MATERIAL.— The female holotype, male allotype, and five paratypes were taken at the type locality in VIII-1967, from *Pinus echinata* cones.

The holotype, allotype, and paratypes are in my collection.

Lymantor alaskanus, n. sp.

This species is distinguished from *decipiens* (LeConte) by the larger size and more slender body, by the different male frons as described below, by the smaller, less deeply impressed pronotal and elytral punctures, and by the different elytral declivity.

MALE.— Length 1.9 mm (paratypes 1.7-1.8 mm), 2.9 times as long as wide; color reddish brown.

Frons strongly convex from slightly below upper level of eyes to vertex, lower two-thirds of area below upper level of eyes transversely impressed (less strongly but much more extensively than in *decipiens*); surface shining, punctures rather fine, moderately close except very sparse on median fourth; vestiture fine, short, inconspicuous.

Pronotum 1.25 times as long as wide; outline as in *decipiens* except sides more strongly converging posteriorly on posterior half; surface smooth, shining, punctures slightly finer, not as deep as *decipiens*.

Elytra 1.8 times as long as wide, 1.8 times as long as pronotum; as in *decipiens* except discal punctures slightly smaller, much less strongly impressed, declivity more evenly convex, striae 1 and 2 not impressed with punctures in rows, smaller than on disc, interstriae 1 much less strongly elevated, 2 not impressed, 2 and 3 each with a sparse row of very fine punctures, their upper margins much more feebly granulate, vestiture finer, shorter, more regularly present from base to apex.

FEMALE.— Similar to male except transverse frontal impression not as deep, upper area less strongly convex.

TYPE LOCALITY.— Bonanza Creek, 30 miles southwest of Fairbanks, Alaska.

TYPE MATERIAL.— The male holotype, female allotype, and 17 paratypes were taken at the type locality on 18-VII-1978, from a sticky trap baited with Ipenol and Alpha-pinene, No. 51, by R. A. Werner.

The holotype, allotype, and paratype are in my collection.

Pityophthorus delicatus, n. sp.

This species is distinguished from *cacuminatus* Blandford by the larger size, by the much more finely punctured subconcave female frons, by the sparsely punctured discal interstriae 1 and 3, and by other characters indicated below.

FEMALE.— Length 2.0 mm (paratypes 1.7-2.2 mm), 3.0 times as long as wide; color reddish brown.

Frons broadly, shallowly subconcave from epistomal margin to well above upper level of eyes, margins abrupt, about two diameters of a facet from margin of eye; surface smooth, shining, very finely, somewhat closely punctured, interspaces two or more times diameter of a puncture; vestiture abundant, rather long in central area, conspicuously longer on margins, longest setae equal in length to two-thirds distance between eyes.

Pronotum 1.14 times as long as wide; outline as in allied species; posterior areas shining, subreticulate, punctures fine, those on disc with a fine granule on lateral rim.

Elytra 1.9 times as long as wide, 1.7 times as long as pronotum; outline and disc about as in *cacuminatus* except interstriae 1 and 3 with sparse punctures. Declivity steep, moderately bisulcate, moderately acuminate behind; striae 1 and 2 rather finely punctured; interstriae 1 moderately elevated, armed by a row of fine tubercles, 2 moderately impressed, twice as wide as 1, smooth, shining, 3 rather narrowly convex, armed as on 1. Vestiture of fine, short, strial hair to base, odd-numbered interstriae on and near declivity with rather sparse, moderately long setae.

MALE.— Similar to female except frons shallowly, transversely impressed from epistoma to upper level of eyes, upper margin of impressed area with a short, transverse callus or carina, surface rather coarsely punctured, vestiture inconspicuous; declivity more strongly impressed, tubercles distinctly larger.

TYPE LOCALITY.— Thirty-five miles or 56 km southwest of El Salto, Durango, Mexico.

TYPE MATERIAL.— The female holotype, male allotype, and two paratypes were taken at the type locality on 23-VII-1953, 8400 ft, No. 129, *Pinus*, S. L. Wood. Other paratypes were taken as follows: two, 48 km or 30 miles NE El Salto, No. 133, other data as on type; seven paratypes Durango, Durango, Mexico, 24-III-1974, M. M. Furniss; one, 96 km or 60 miles W Durango, Durango, Mexico, 5-VI-1965, No. 29, *Pinus*, S. L. Wood; one, 5 km or 3 miles W El Salto, Durango, Mexico, 19-VI-1965, No. 40, *Pinus*, S. L. Wood; four, 29 km or 18 miles N San Juanito, Chihuahua, Mexico, 4-V-1977, *Pinus*, M. M. Furniss; nine, 9 km or 6 miles E Volcan Paracutin, 19-VI-1965, No. 82, *Pinus*, S. L. Wood; ten, 32 km or 20 miles NW Comitan, Chiapas, Mexico, 17-VI-1964, No. 709, *Pinus*, S. L. Wood; five, Chelum Chauel, Cuchmatanes, Huchuetenango, Guatemala, 19-IV-1972, E. W. Clark; three, Patzum, Guatemala, 26-IX-1974, *Pinus tenuifolia*, R. Lühl; six, Tegucigalpa, Honduras, 9-III-1966, *Pinus oocarpa*.

In the Honduras series the elytral declivity is slightly steeper and the female frons is more nearly convex, with the frontal punctures averaging slightly larger.

The holotype, allotype, and paratypes are in my collection.

Pityophthorus rubidus, n. sp.

This species is distinguished from *spadix* Blackman by the stouter body, by the reddish brown color, by the confused discal punctures and the less strongly acuminate elytral apex, and by other characters indicated below.

FEMALE.— Length 2.3 mm (paratypes 2.3–3.0 mm), 2.6 times as long as wide; color reddish brown.

Frons planoconvex to slightly above eyes, ascending toward epistoma on lower fifth particularly on median third, margins rounded, about three diameters of a facet from margin of eye; surface smooth, shining, rather finely, closely, uniformly punctured, interspaces in central area equal in width to diameter of a puncture, less than half as great in marginal areas; vestiture of fine, moderately abundant long hair, longest setae about equal in length to half distance between eyes.

Pronotum 1.12 times as long as wide; widest at base, sides on posterior two-thirds feebly arcuate, moderately converging to rather narrowly rounded anterior margin; anterior margin armed by about 10–14 low serrations; summit at middle, rather high; posterior areas smooth, shining, with numerous impressed points, punctures coarse, deep, close. Glabrous on disc, sparse hair on sides and asperate area.

Elytra 1.6 times as long as wide, 1.5 times as long as pronotum; sides almost straight and parallel on basal three-fourths, rather abruptly rounded at base of declivity, strongly acuminate behind; striae 1 weakly impressed, rows obscurely visible, largely confused, punctures rather coarse, deep, close. Declivity very steep, rather strongly bisulcate, strongly acuminate at apex; striae 1 and 2 rather coarsely punctured; interstriae 1 moderately elevated, armed by a row of small tubercles, 2 twice as wide as 1, almost smooth, shining, impunctate, 3 on upper half slightly higher than 1, armed by 6–10 rather coarse, closely spaced tubercles. Vestiture on posterior third of disc and declivity long, moderately abundant on all interstriae.

MALE.— Similar to female except frons transversely impressed to upper level of eyes, a strong transverse carina at upper level of eyes, surface coarsely punctured, vestiture inconspicuous; declivital tubercles slightly larger.

TYPE LOCALITY.— Madera Canyon, Santa Rita Mountains, Arizona.

TYPE MATERIAL.— The female holotype, male allotype, and 68 paratypes were taken at the type locality on 1-V-1978, from *Pinus engelmanni* branches, by me. Other paratypes were taken as follows: six, 35 km or 23 miles W Durango, Durango, Mexico, 4-VI-1965, No. 14, *Pinus* probably *engelmanni*, S. L. Wood; three, 48 km or 30 miles NE El Salto, Durango, Mexico, 23-VII-1953, No. 133, *Pinus*, S. L. Wood.

The holotype, allotype, and paratypes are in my collection.

Pityophthorus vesculus, n. sp.

This species is distinguished from *acuminatus* (Schedl) by the smooth, shining, more coarsely punctured pronotum, by the much stouter, almost spatulate interstrial setae on the elytral declivity, and by the more abundant much longer pubescence on the female frons.

Female.— Length 1.5 mm (paratypes 1.3–1.4 mm), 3.0 times as long as wide; color reddish brown.

Frons flattened to well above eyes, margins rounded, separated from eye by distance equal to width of three facets; epistomal margin gradually, distinctly elevated; surface smooth, shining, densely, finely punctured; vestiture of fine, moderately abundant, uniformly distributed, setae little if any longer at margins. Eyes normal, rather finely faceted.

Pronotum 1.2 times as long as wide; sides almost straight and parallel on basal two-thirds, rather broadly rounded in front; anterior margin armed by about 12 low serrations; summit rather indefinite, anterior to middle; asperities on anterior slope confused; posterior areas smooth, shining, punctures moderately coarse, numerous impressed points present. Glabrous except on asperate area.

Elytra 1.8 times as long as wide, 1.5 times as long as pronotum; sides straight and parallel on basal two-thirds, rather strongly acuminate behind; striae not impressed, except 1 feebly, punctures rather coarse, close, deep; interstriae slightly wider than striae, smooth, shining, with a few obscure impressed points, impunctate except near declivity. Declivity steep, shallowly bisulcate; striae 1 and 2 with punctures almost as coarse as on declivity; interstriae 1 distinctly elevated, granules minute, almost obsolete, 2 shallowly impressed, as wide as 1, smooth, shining, impunctate, 3 as high as 1, armed on upper half by two small, pointed tubercles. Vestiture confined to declivity, of stout rather short, interstrial setae, absent on 2.

Male.— Similar to female except frons convex, a slight transverse impression on lower third, surface smooth, shining, coarsely punctured, vestiture inconspicuous; declivital sulcus stronger, tubercles on interstriae 1 and 3 distinctly larger, declivital vestiture much stouter, almost spatulate.

Type Locality.— Fort Clayton, Canal Zone, Panama.

Type Material.— The female holotype, male allotype, and three paratypes were taken at the type locality on 22-XII-1963, 30 m, No. 325, from the bark of a bole 25 cm in diameter (large, simple leaves 25 cm long), by me.

The holotype, allotype, and paratypes are in my collection.

Scolytodes comitabilis, n. sp.

This species is distinguished from *fulmineus* Wood by the smaller size, by the more coarsely asperate anterior slope of the pronotum, by the coarser strial and interstrial punctures, and by the different female frons.

Female.— Length 1.5 mm (paratypes 1.5–1.7 mm), 2.5 times as long as wide; color very dark brown.

Frons rather strongly convex from just above epistoma to vertex; surface smooth, shining to upper level of eyes, reticulate above eyes, punctures sparse, minute; vestiture short, sparse, inconspicuous, limited to lateral thirds on lower half.

Pronotum outline as in *fulmineus*, anterior two-fifths much more coarsely asperate, basal half more coarsely, more deeply punctured.

Elytral outline as in *fulmineus* except declivity steeper, strial punctures coarser (interstriae as wide as striae), fine interstrial punctures distinct, regularly spaced, vestiture slightly more abundant (sparse rows on odd-numbered interstriae, mostly on posterior half.

Male not recognizable, although probably present in type series.

Type Locality.— Merida, Merida, Venezuela.

Type Material.— The female holotype and 16 paratypes were taken at the type locality on 22-IX-1969, 1700 m, No. 9, *Clusia* twigs, by me.

The holotype and paratypes are in my collection.

Scolytodes crinalis, n. sp.

This species is distinguished from the remotely allied *varius* Wood by the smaller size, by the stouter, more finely punctured pronotum, and by other characters cited below.

FEMALE.— Length 2.3 mm (paratypes 2.0–2.5 mm), 2.2 times as long as wide; mature color almost black.

Frons moderately, transversely impressed from epistoma to level of antennal insertion, convex above, a rounded median tubercle on epistoma; surface reticulate, punctures fine, rather sparse; vestiture moderately short, rather sparse, inconspicuous.

Pronotum 1.1 times as long as wide; widest in front of middle, sides feebly constricted on basal half, rather broadly rounded in front; surface uniformly, rather strongly reticulate, punctures fine, rather deep, spaced by two to four diameters of a puncture. Vestiture rather abundant, fine, moderately long, semirecumbent.

Elytra 1.5 times as long as wide, 1.8 times as long as pronotum; outline as in *varius*; surface smooth, shining, strial punctures in obscure rows, punctures small; interstriae with punctures similar to those of striae, confused, about five times as wide as striae. Declivity steep, convex, sculpture as on striae except punctures half as large. Vestiture of rather abundant, moderately long, recumbent strial and interstrial hair, and poorly defined interstrial rows of longer, erect hair, those on odd-numbered interstriae longer and more regular.

MALE.— Similar to female except frontal impression reduced, convexity extending almost to median epistomal tubercle; elytral vestiture slightly longer; erect interstrial setae less well defined.

TYPE LOCALITY.— La Carbonera Experimental Forest, 50 km (airline) NW Merida, Merida, Venezuela.

TYPE MATERIAL.— The female holotype, male allotype, and eight paratypes were taken at the type locality on 14-X-1969, 2500 m, No. 50c, from *Clusia* branches, by me.

The holotype, allotype, and paratypes are in my collection.

Scolytodes crinitus, n. sp.

This species is distinguished from *punctifer* Wood by the reticulate more finely punctured pronotum, by the finer elytral punctures, and by the longer, more nearly erect elytral setae.

FEMALE.— Length 1.4 mm (paratypes 1.3–1.6 mm), 2.2 times as long as wide; mature color almost black.

Frons as in *punctifer* except with fewer setae.

Pronotum as in *punctifer* except surface reticulate, punctures much smaller, spaced by one to three diameters of a puncture (less than one in *punctifer*).

Elytra about as in *punctifer* except strial punctures slightly larger, deeper, interstrial punctures all uniseriate, half as large as those of striae, erect interstrial setae in more definite rows, finer, slightly longer, all setae in more definite rows.

MALE.— Similar to female except frons more strongly convex.

TYPE LOCALITY.— El Laurel Experimental Farm, 12 km southeast of Caracas, Venezuela.

TYPE MATERIAL.— The female holotype, male allotype, and 72 paratypes were taken at the type locality on 1-V-1970, No. 464, from a leguminous vine, by me.

The holotype, allotype, and paratypes are in my collection.

Scolytodes decorus, n. sp.

This species is distinguished from the remotely allied *habilis* Wood by the narrower, smoother, more shining frons, by the more coarsely, deeply punctured elytra, and by all elytral vestiture being in recognizable rows.

MALE.— Length 1.5 mm (paratypes 1.5–1.7 mm), 2.25 times as long as wide; color very dark brown.

Frons slightly narrower than *habilis*, its lower half not reticulate, smooth, shining, punctures larger, deeper.

Pronotum 1.0 times as long as wide; surface strongly, uniformly reticulate, punctures as large as *habilis* but less dense, spaced on basal half by one to two diameters of a puncture.

Elytra 1.5 times as long as wide, 1.9 times as long as pronotum; striae and interstriae in recognizable rows, striae not impressed, punctures rather coarse, deep, close; interstriae as wide as striae, punctures almost as large and as close; surface smooth and shining. Declivity steep, convex; as on disc except punctures slightly smaller, rows less evident. Vestiture of rather short, subequal strial and interstrial hair, always erect on interstriae, half of those on striae erect, half semirecumbent, longest setae equal to two-thirds length of distance between interstrial rows.

FEMALE.— Similar to male except almost all strial setae erect. Frons not visible in allotype, concealed by pronotum.

TYPE LOCALITY.— Forty km east Canton, Barinas, Venezuela.

TYPE MATERIAL.— The male holotype, female allotype, and two paratypes (one with head and prothorax missing) were taken at the type locality on 8-III-1970, 70 m, No. 332, from *Nectandra* branches, by me.

The holotype, allotype, and paratypes are in my collection.

Scolytodes genialis, n. sp.

This species is distinguished from *tolimanus* (Schedl) by the smaller size, by the different pronotal tubercles, by the more numerous impressed lines on the elytral disc, by the smaller elytral punctures, and by the more evenly convex declivity.

FEMALE.— Length 2.0 mm (paratypes 1.8–2.3 mm), 2.3 times as long as wide; mature color almost black.

Frons broadly convex except for slight, short, transverse impression, immediately above epistoma, a distinctly elevated, obtuse median carina on lower half; surface reticulate, punctures rather coarse, moderately close, distinct; vestiture short, sparse, inconspicuous.

Pronotum outline as in *tolimanus*; surface reticulate, punctures on basal half small, deep, spaced by one to two diameters of a puncture, most with a shining lateral margin, these margins on anterior half form rounded granules that gradually increase in size and replace punctures before anterior margin. Vestiture of fine, rather short hair, often abraded.

Elytra 1.4 times as long as wide, 1.6 times as long pronotum; disc modestly wrinkled on basal third, smooth, shining behind; striae with punctures in somewhat obscure rows; interstriae four times as wide as striae, punctures slightly smaller than those of striae, in slightly irregular rows. Declivity steep, broadly convex; punctures confused, smaller than on disc. Vestiture consisting of short, recumbent strial and interstrial hair on disc and declivity, some interstrial setae on disc distinctly longer and tending to be semierect.

MALE.— Similar to female except frons more distinctly convex, lower half of carina more stringly elevated.

TYPE LOCALITY.— Thirty km north of Merida, Merida, Venezuela.

TYPE MATERIAL.— The female holotype, male allotype, and 106 paratypes were taken at the type locality on 8-I-1970, 2200 m, No. 224, from a cucurbit vine, by me. Four paratypes bearing similar data were No. 223 in *Podocarpus* twigs.

The holotype, allotype, and paratypes are in my collection.

Scolytodes habilis, n. sp.

This species is distinguished from *hirsutus* Wood by the more slender form, by the more strongly reticulate, much more coarsely punctured pronotum, by the shorter vestiture, and by other characters.

FEMALE.— Length 1.7 mm (paratypes 1.5–1.8 mm), 2.3 times as long as wide; color almost black.

Frons as in *hirsutus* except less strongly convex, with no indication of a median summit, vestiture shorter, less conspicuous.

Pronotum 1.04 times as long as wide; outline about as in *hirsutus* except more slender; surface strongly, uniformly reticulate, coarsely, closely, rather deeply punctured on basal half, punctures becoming smaller on anterior third, without any indication of granules; spaces between punctures on basal half less than diameter of a puncture, one to three times as great on anterior fourth. Vestiture half as long as in *hirsutus*.

Elytra 1.5 times as long as wide, 1.7 times as long as pronotum; discal punctures much as in *hirsutus*, except twice as large. Declivity shorter and much steeper than in *hirsutus*, surface obscurely subreticulate, punctures confused, close, conspicuously smaller than on disc. Vestiture rather abundant, recumbent, each setae about equal in length to three times diameter of a puncture; a few setae on odd-numbered interstriae erect, but little if any longer.

MALE.— Similar to female except frons more distinctly convex; erect setae on odd-numbered discal interstriae more numerous and slightly longer.

TYPE LOCALITY.— Thirty km east of Merida, Merida, Venezuela.

TYPE MATERIAL.— The female holotype, male allotype, and 11 paratypes were taken at the type locality on 8-I-1970, 2500 m, No. 220, from *Croton*; 3 paratypes are from La Mucuy, 20 km W Merida, Merida, Venezuela, 12-XI-1969, 2500 m, No. 129, tree branch. All were taken by me.

The holotype, allotype, and paratypes are in my collection.

Scolytodes libidus, n. sp.

This species is distinguished from *genialis* Wood by the smaller size, by the more slender form, by the coarser pronotal punctures which lack a lateral, smooth, shining margin, by the recognizable rows of strial and uniseriate interstrial punctures to base, and by the longer, more erect elytral hair.

FEMALE.— Length 1.8 mm (paratypes 1.5–1.8 mm), 2.4 times as long as wide; color almost black.

Frons as in *genialis* except slightly narrower, slightly more convex.

Pronotum 1.07 times as long as wide; as in *genialis* except punctures on basal half mostly without lateral shining margin.

Elytra 1.4 times as long as wide, 1.45 times as long as pronotum; as in *genialis* except disc smooth, strial punctures slightly larger, declivital punctures slightly larger, vestiture longer, more abundant, mostly erect; longest interstrial setae as long as distance between rows, spaced within a row by half that distance; strial setae on declivity tend to be recumbent.

MALE.— Similar to female except asperities on anterior margin of pronotum slightly larger, more conspicuous.

TYPE LOCALITY.— Rancho Grande, Pittier National Park, Aragua, Venezuela.

TYPE MATERIAL.— The female holotype, male allotype, and 15 paratypes were taken at the type locality on 9-IV-1970, 1100 m, No. 407, Cucurbit vine. Other paratypes from Venezuela include: 3 from No. 421 and 15 from No. 422 with all other data as on the type; 22 from Merida, Merida, 11-X-1969, 1700 m, No. 1, Cucurbit vine. All were taken by me.

The holotype, allotype, and paratypes are in my collection.

Scolytodes perpusillus, n. sp.

This species is distinguished from *libidus* Wood by the much smaller size, by the absence of a frontal carina, by the finer pronotal punctures, and by the spatulate, erect interstrial setae.

FEMALE.— Length 1.2 mm (paratypes 1.1–1.3 mm), 2.3 times as long as wide; color very dark brown.

Frons rather strongly convex, a longitudinally short, distinct, transverse impression immediately above epistoma; surface reticulate, punctures moderately abundant, rather coarse; vestiture short, sparse, inconspicuous.

Pronotum 0.88 times as long as wide; widest at middle; sides moderately arcuate, broadly rounded in front, basal margin bisinuate; surface reticulate; anterior slope with low, isolated, rounded granules; basal half with rather abundant, moderately fine, shallow punctures; vestiture of rather abundant, short, fine hair.

Elytra 1.3 times as long as wide, 1.6 times as long as pronotum; sides weakly arcuate on basal two-thirds, rather broadly rounded behind; basal third of disc slightly wrinkled; striae not impressed, punctures small, shallow; interstriae three to four times as wide as striae, rather smooth, subshining, punctures uniseriate, smaller than those of striae, shallow. Declivity steep, convex; sculpture much as on disc, with punctures finer, those on interstriae somewhat confused. Vestiture of fine rather short recumbent hair; approximately every third or fourth interstrial seta an erect, subspatulate bristle, these erect setae forming an interstrial row, erect setae as long as distance between rows, spaced within a row by one to three times this distance.

Male.— Similar to female except erect interstrial setae more regular, very slightly longer.

Type Locality.— Rancho Grande, Pittier National Park, Aragua, Venezuela.

Type Material.— The female holotype, male allotype, and eight paratypes were taken at the type locality on 9-IV-1970, 1100 m, No. 443, from a tree branch by me.

The holotype, allotype, and paratypes are in my collection.

Scolytodes semipunctatus, n. sp.

This species is distinguished from *punctatus* Eggers by the much more finely punctured frons, pronotum, and elytra and by the much shorter vestiture.

Female.— Length 2.0 mm (paratypes 1.7–2.0 mm), 2.2 times as long as wide; color very dark brown, elytra on some specimens lighter brown.

Frons as in *punctatus* except punctures smaller, not as deep; lateral areas more strongly reticulate.

Pronotum outline and form as in *punctatus* except surface more strongly, more uniformly punctured, punctures less than half as large, shallow, not clearly formed, vestiture slightly shorter.

Elytra outline and form as in *punctatus* except strial punctures two-thirds as large, interstrial punctures half as large, punctures even smaller on declivity, vestiture half as long except one-third as long on declivity.

Male.— Similar to female except frons slightly narrower, median summit more evident, obscurely more strongly convex.

Type Locality.— Merida, Merida, Venezuela.

Type Material.— The holotype, allotype, and 10 paratypes were taken at the type locality (between stations 1 and 2 of the Teleferico) on 27-II-1970, 2500 m, No. 331, from the bole of a small tree having simple leaves up to 50 cm in length, by me.

The holotype, allotype, and paratypes are in my collection.

NEW RANGE AND A NEW SUBSPECIES FOR THE SNAKE *ERIDIPHAS SLEVINI*

John R. Ottley[1] and Wilmer W. Tanner[1]

Abstract.— Additional specimens of *Eridiphas slevini* from Baja California del Sur are reported and discussed and the first specimen from Baja California del Norte is reported. Specimens from San Marcos Island are distinguished from mainland stock with the description of the new subspecies *E. s. marcosensis.*

Of the few reported specimens of *Eridiphas slevini* (Tanner), most have been taken in the Cape region of Baja California, including Cerralvo Island. Tanner (1943) in his description of the species *Hypsiglena slevini,* stated that the holotype (CAS 53631) was collected at Puerto Escondido in Baja California by Joseph R. Slevin on 14 June 1921. A second specimen (CAS 86093) was collected in January 1959 by Dr. Alan E. Leviton and Mr. Hugh B. Leech from a rivulet in the El Saltito Arroyo, 12 miles east of La Paz (Leviton and Tanner 1960). Soulé (1961) reported the occurrence of the species on Cerralvo Island, the specimen (CAS 88985) having been collected on 6 March 1960 by Dr. Michael E. Soulé and Mr. Robert Crippen (Etheridge 1961).

Specimens remain scarce in collections, but recent field work has produced a series from a wide geographical area, including the San Ignacio-Santa Rosalia area of Baja California del Sur.

Specimens from this area are, first, an adult female (BYU 33672) taken alive on 26 August 1977 at 2300 hours, 17.1 miles (by Mexican Highway 1) NW Santa Rosalia. A second adult female (CAS 146498) was collected on 14 September 1977, 18 miles (by Mexican Highway 1) NE Santa Rosalia by Robert L. Seib. Two additional adult female specimens (CAS 146499 by R. L. Seib and BYU 34618) were collected 7.6 miles (by Mexican Highway 1) on 7 May 1978 and 7.0 miles (by Mexican Highway 1), 2130 hours on 7 June 1978, respectively, E San Ignacio. A juvenile male (BYU 34651), was taken S Santa Rosalia, 2.2 miles W the village of Santa Agueda on 14 June 1978 at 2140 hours as it was foraging along a streambed at the base of an aqueduct.

A specimen of *E. slevini* was recently discovered near Bahia de los Angeles, Baja California del Norte. This specimen, a juvenile male (BYU 36415), was collected as it lay coiled in a small basal fissure of a boulder in a dry and narrow, rock-strewn wash, about 0.5 miles north of the paved road at a point 9.2 miles (by road) west of the resort at Bahia de los Angeles.

It is of interest to note that although a number of additional specimens have been collected from various locations in the Cape region since the last specimen was reported by Soulé (1961), none have reached the literature. Of three specimens on hand at the San Diego Society of Natural History Museum, two were collected north of Cabo San Lucas at Rancho La Burrera (SDSNH 45032) and La Burrera of La Laguna (SDSNH 45213) in August 1961 and September 1965, respectively, by Mr. Trinidad Castillo and Mr. A. Agundes. The third specimen (SDSNH 46051) was collected at Rancho Fragua in Arroyo Fragua, 15 miles northwest of Loreto on 2 October 1967 by Mr. Reid Moran. Before the range extension to San Ignacio, the locality for SDSNH 46051 had, in all probability, been the most northerly point known for the species. A juvenile female specimen (BYU 34652) collected between Loreto and Puerto Escondido at the fishing village known as Juncalito on 20 June 1978 at 2145 hours may be from the same arroyo as the specimen collected by Slevin in 1921. Another specimen (CAS 134804) is an adult male collected S La Paz, 3 km S San Bartolo on 1 July 1972 by Ted Papenfuss.

---

[1] Life Science Museum, Brigham Young University, Provo, Utah 84602.

The range of *E. slevini* is now known to include Danzante Island. That specimen (CAS 140097) is an adult female collected during July 1974 by Steven Strand.

Included with the material from the San Ignacio-Santa Rosalia area are two specimens from San Marcos Island. Both were collected in the large Arroyo de la Taneria adjacent to the gypsum mine on the island by one of us (JRO). These specimens constitute a new insular record and bear characters which distinguish them from the presently known mainland stock.

Eridiphas slevini marcosensis, subsp. nov.

Holotype.— BYU 34617, an adult female collected from a talus slope on the south side of Arroyo de la Taneria on San Marcos Island at 2130 hours on 18 June 1978.

Paratype.— BYU 34616 an adult female collected from a flat wash near the goat corrals in Arroyo de la Taneria at 2155 hours on 2 June 1978.

Diagnosis.— A subspecies closely related to and apparently derived from the mainland *Eridiphas slevini*, from which it can be distinguished in having a greater number of ventral scales, dorsal blotches, and small head size.

Description of holotype.— An adult female, total length 467 mm, tail 83 mm, head 17.5 mm, snout length 4.5 mm, diameter of orbit 3.0 mm; ratio of tail length to total length 17.95 percent, head into body 4.56 percent.

Scale rows on body 21-23-19, on the tail at the 15th subcaudal 6 rows; ventrals 200, subcaudals 61, anal divided; supralabials 8-8, infralabials 10-10; preoculars 2-2, upper preocular 3 times longer than lower; postoculars 2-2 with parietals in contact with lower, temporals 1 + 2, loreals 1-1, nasal divided, rostral wider (3.1 mm) than high (1.3 mm); 14 maxillary teeth.

First pair of infralabials in broad contact on the midventral line, surrounding the mental and wedging posteriorly between the anterior pair of genials; genial size moderate, posterior pair slightly more elongate than anterior pair, the first five infralabial pairs contacting anterior genials, the fifth and sixth pairs in contact with posterior genials; three gulars between posterior genials and first ventral.

Dorsal pattern consists of five longitudinal rows (six rows at midbody) of dark gray-brown spots on a brown-gray ground color, dorsal rows on body of 65 spots, 28 on tail, some of which are divided or partially divided at the dorsal midline, each spot involving 13 to 20 scales, center of spots lighter than margins; lateral spots smaller, involving 1–5 scales all dark gray-brown; scales involved in ground color have light colored edges, scales between middorsal spots being lightest.

Nape pattern composed of five spots; a median spot 4 scales long and about 2.5 scales wide, separated from parietals by a single scale, two round spots at each side of median spot involve 12 to 13 scales each, two posterior nape spots are elongate and in line with spots on dorsal midline, separated from one another by a single row of light-edged scales and from anterior nape spots by 1–1.5 scales. Elongate lateral spots begin on the last supralabial and last two infralabials, pass under anterior nape spots upward to and separated from the posterior nape spots (by less than one scale); a postocular stripe extends from orbit through lower postocular to reach mouth on the 6th and 7th supralabials; supralabials are cream colored with small dark gray-brown spots on anterior-posterior edges, infralabials are similar with less dark color; parietals, frontal, and supraoculars have fine irregular dark gray-brown blotches; gulars, lateral edges of ventrals and subcaudals finely flecked, chin shields, central of ventrals and subcaudals are immaculate yellow-gray.

Variation.— Single paratype similar to holotype in nearly all details. Color pattern slightly faded yet discernable. Ventral count lower, with 198, but higher than ventral counts for mainland specimens. Tail incomplete, with only 23 subcaudals. Temporals 2 + 2 due to a small scale between each large primary temporal and 6th supralabials. Head to body ratio 4.69 percent (4.56 percent in holotype). This ratio indicates a smaller head size in *E. s. marcosensis* (Table 1).

SIZE.— *Eridiphas slevini* is small to moderate in size; the largest specimen measured from the penninsula is 562 mm in total length, 102 mm for the tail and a snout-vent length of 460 mm (SDSNH 45213). The smallest specimen is 213 mm in total length, 40 mm for tail (CAS 53631). The paratype for *E. s. marcosensis* (BYU 34616) is the largest specimen measured, having a snout-vent length of 481 mm and with a total length of 524 mm; however, more than half of the tail is missing, with only 43 mm remaining.

REMARKS.— The data presented in Table 1 indicate a trend for a higher number of ventral and subcaudal scutes toward the north. The exceptions are BYU 34651 from Santa Agueda, with a low count of 182 ventrals, and SDSNH 46051 from near Loreto, with a high count for the Cape Region of 192 ventrals. The most variable characters appear to be counts for ventrals, subcaudals, and dorsal blotches, and head to body ratios. Temporal formulas appear to be of little value because a random variation is seen throughout the range. There is no overlap between *E. s. marcosensis* and mainland stock involving ventral counts, the number of dorsal blotches, and head size. However, subcaudals are well within the given range and head to body ratios for *E. s. marcosensis* and the Cerralvo Island specimen are similar.

Several specimens bear peculiarities demonstrating a certain amount of genetic plasticity. The Danzante Island specimen is more darkly colored than other specimens seen and its pattern is indistinct, a character also observed in the paratype of *E. s. marcosensis*. One specimen from near San Ignacio (CAS 146499) does not bear the parietal-lower postocular contact characteristic of the genus. The separation is caused by what appears to be the formation of an extra scale of minute proportion from the lower fold of each parietal. Also the anal plate is divided twice to form three parts. The specimen from near San Bartolo (CAS 134804) has heavy nuchal blotches similar to *Hypsiglena* and a low count for dorsal scales of 21 rows. The specimens from La Burrera (SDSNH 45032 and SDSNH 45213) also bear lower dorsal scale counts, with 22 and 21 rows respectively.

DISCUSSION

The new material from the San Ignacio-Santa Rosalia area extends the range of *Eridiphas slevini* approximately 130 miles northward from the area at Puerto Escondido given by Leviton and Tanner (1960). The Bahia de los Angeles specimen repre-

TABLE 1. Variations in scale counts, body blotches, body proportions, and ratios of *Eridiphas slevini*[1].

	Cape region[2]	Cerralvo Island[3]	Danzante Island	San Ignacio-Santa Rosalia	Bahia de los Angeles	San Marcos Island
Ventrals	187.8(184-192)6	186	195	190.8(182-194)5	193	199(198-200)2
Subcaudals	61.3(55-67)6	58	62	64.5(61-68)4	65	61
Dorsal scale rows	22.2(21-23)6	23	23	23(23)5	23	23(23)2
Supralabials	8(8)12	8-8	8-8	8(8)10	8-8	8(8)4
Infralabials	10(10)12	10-10	10-10	10(10)10	10-10	10(10)4
Loreals	1(1)12	1-1	1-1	1(1)10	1-1	1(1)4
Preoculars	2(2)12	2-2	2-2	2(2)10	2-2	2(2)4
Postoculars	2(2)12	2-2	2-2	2(2)10	2-2	2(2)4
Temporals	1.1+2.6(1-2+2-3)12	1+2	1+3	1+2.4(1+2-3)10	1+2	1.5+2(1-2+2)4
Dorsal blotches	56.6(51-61)6	63	58	58.8(55-63)5	61	65(65)2
Tail length/ total length	17.81%(16.5%-19.2%)6	16.1%	18.55%	18.35%(17.45%-18.15%)4	17.9%	17.76%
Head length/ total length	5.08%(4.78%-5.56%)5	4.66%	4.84%	5.7%(4.95%-5.22%)4	—	4.63%(4.56%-4.69%)2

[1] Juvenile specimens are not used in head to body ratios.
[2] Includes data from Leviton and Tanner (1960); does not include BYU 34652 from Loreto.
[3] From Soulé (1961).

sents an additional northerly extension of nearly 100 miles. Northerly progression probably occurred along the eastern third of the peninsula, avoiding the more barren Viscaino Desert to the west.

The possibility must be noted that we may be dealing with an isolated population in the Bahia de los Angeles region even though BYU 34615 is not significantly distinct. *Eridiphas* seems to prefer a more temperate climate as do *Lichanura, Elaphe,* and *Tantilla. Lichanura* is not presently known to have a zone of intergradation, the populations of the Central Desert and San Ignacio being separated by approximately 100 miles (Gorman 1965, Bostic 1971). *Elaphe rosaliae* occupies a range nearly identical to *Eridiphas* in Baja California del Sur (Savage 1960). Specimens of *Elaphe rosaliae* in Baja California del Norte discovered by Hunsaker (1967) in Guadalupe Canyon are indicatory of a disjunct northern population of that species and presents a clue as to the possible occurrence of *Eridiphas* in more northerly areas than those localities presently known. It is interesting to note as well, the discovery of the recently described gecko *Anarbylus* (Murphy 1974) in southern California (Fritts, pers. comm.), another indication that many of the southern forms may range well into the north.

The four specimens collected between San Ignacio and Santa Rosalia were taken from only two sites along Mexican Highway 1. Populations also occur near Bahia de los Angeles, Loreto, and La Paz. Although present data are meager, such evidence suggests a spotty distribution for *E. slevini,* a condition possibly created by competition pressures imposed by the more recent arrival of other genera. This idea adds strength to the hypothesis that *E. slevini* represents a relict form and probable progenitor of the modern genera *Hypsiglena* and *Leptodeira* (Leviton and Tanner 1960).

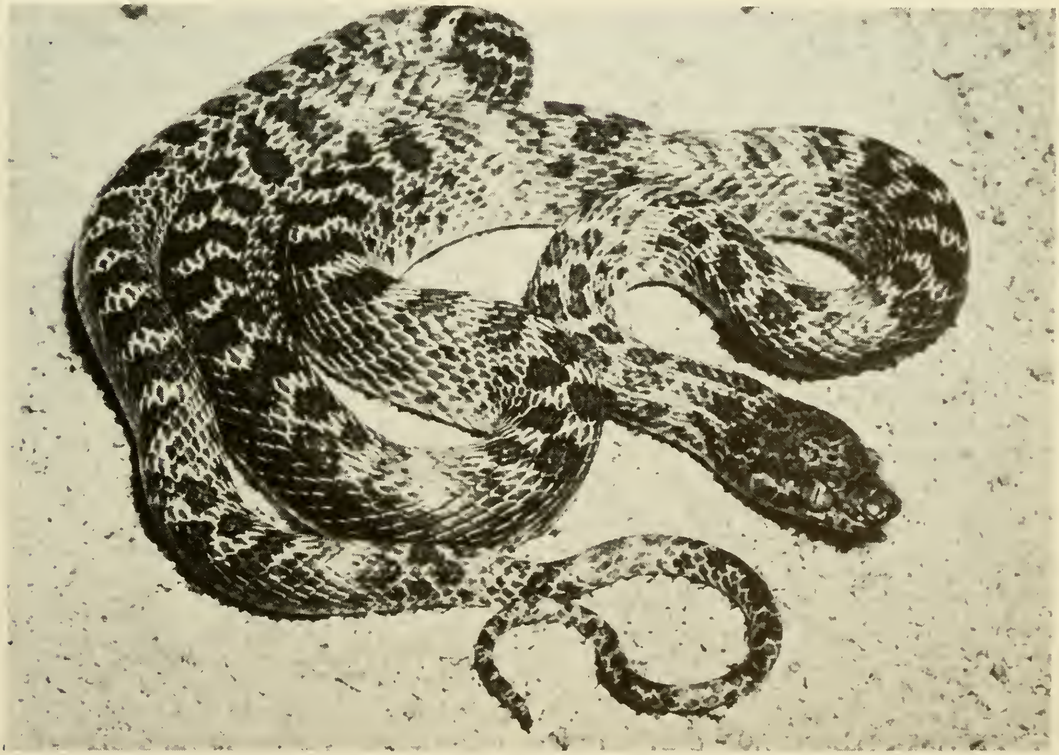


Fig. 1. Dorsolateral view of *Eridiphas slevini marcosensis* holotype, BYU 34617 (photo courtesy of John H. Tashjian).

Acknowledgments

Fieldwork was partially supported by the Associated Students of Brigham Young University Student Research Fund. Our thanks are extended to Mr. Robert W. Murphy and Mr. John C. Cram for their faithful assistance and company while in the field. Dr. Thomas Fritts of the San Diego Society of Natural History Museum and Dr. Alan E. Leviton of the California Academy of Science were kind enough to loan specimens. Mrs. Gail Olsen and Mrs. Vickie R. Ottley typed the manuscript. Mr. John H. Tashjian photographed the holotype and furnished Figure 1. Mr. Brian Hatch prepared the map for Figure 2. The Scientific Collecting Permit was provided by Dr. Antonio Landazuri Ortiz, Director General, Fauna Silvestre Departamento de Conservacion, Mexico, D. F. Sincere gratitude is expressed to Mr. Antonio Chavez and his wife, whose warm hospitality during our stay on San Marcos Island will be long remembered.

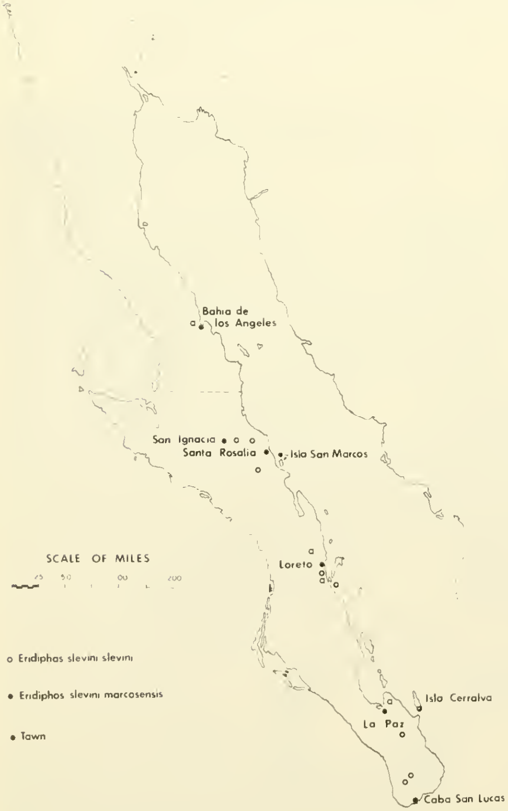


Fig. 2. Distribution of *Eridiphas slevini* on the Baja California peninsula and neighboring islands.

Literature Cited

Bostic, D. L. 1971. Herpetofauna of the Pacific Coast of north central Baja California, Mexico, with a description of a new subspecies of *Phyllodactylus xanti*. San Diego Soc. Nat. Hist., Trans. 16(10):237-263.

Duellman, W. E. 1966. Remarks on the systematic status of certain Mexican snakes of the genus *Leptodeira*. Herpetologica 22(2):97-106.

Etheridge, R. 1961. Additions to the herpetological fauna of Isla Cerralvo in the Gulf of California, Mexico. Herpetologica 17(1):55-60.

Gorman, G. C. 1965. The distribution of *Lichanura trivirgata* and the status of the species. Herpetologica 21(4):283-287.

Hunsaker, D. 1965. The Ratsnake *Elaphe rosalie* in Baja California. Herpetologica 21(1):71-72.

Kelly, K. L. 1958. ISCC-NBS color-name charts illustrated with centroid colors. National Bureau of Standards, NBS Circular 533.

Leviton, A. E., and W. W. Tanner. 1960. The generic allocation of *Hypsiglena slevini* Tanner (Serpentes: Colubridae). Occ. Pap. Calif. Acad. Sci. 27. 7 pp.

Murphy, R. W. 1974. A new genus and species of Eublepharine gecko (Sauria: Gekkonidae) from Baja California, Mexico. Proc. Calif. Acad. Sci. 40:93-109.

Savage, J. M. 1960. Evolution of a peninsular herpetofauna. *In sumposium*: The biogrography of Baja California and adjacent seas. Syst. Zool. 9(3-4):184-212.

Soulé, M. E. 1961. *Eridiphas slevini* (Tanner) on Cerralvo Island, Gulf of California, Mexico. Herpetologica 17(1):610.

Soulé, M. E., and A. J. Sloan. 1966. Biogeography and distribution of the reptiles and amphibians on islands in the Gulf of California, Mexico. San Diego Soc. Nat. Hist., Trans. 14(11):137-156.

Tanner, W. W. 1943. Two new subspecies of *Hypsiglena* from western North America. Great Basin Nat. 4:49-54.

______. 1944. A taxonomic study of the genus *Hypsiglena*. Great Basin Nat. 5:25-92.

A NEW SUBSPECIES OF THE SNAKE *LICHANURA TRIVIRGATA* FROM CEDROS ISLAND, MEXICO

John R. Ottley[1]

Abstract.— A new subspecies, *Lichanura trivirgata bostici*, from Cedros Island, Baja California del Norte, Mexico, is described, figured, and compared to other taxa of the genus.

During an expedition to the islands adjacent to the Pacific coast of Baja California del Norte, Mexico, Mr. Dennis L. Bostic, the late chairman of the Department of Life Sciences at Palomar College, San Marcos, California, collected two unusual specimens of *Lichanura trivirgata* from Cedros Island on 2 February 1974. These specimens represent a new insular record and constitute the second report of the species from a Pacific island, *L. trivirgata* having been previously recorded from Natividad Island (Bostic 1973). The color and pattern of four specimens now available from Cedros Island is significantly distinct from specimens presently known in research collections.

The species and subspecies of *Lichanura* are differentiated primarily by pattern and color, with some attention given to scale characters (Klauber 1931). Klauber noted considerable variation within the genus, but elected to describe the subspecies *L. roseofusca gracia* from desert forms having even edged stripes. Additional material has failed to produce sufficient evidence to change the methods and parameters set by Klauber (Gorman 1965, Bostic 1971). Therefore, the aforementioned trend is continued in the following new subspecies. All descriptive color references are the standardizations of Ridgeway (1912) compared to living specimens.

Lichanura trivirgata bostici, subsp. nov.
Cedros Island Boa

Holotype.—BYU 41385, an adult male, from the Gran Cañon on the eastern shore of Cedros Island, Baja California del Norte, Mexico, collected approximately 10 m above the tide line from beneath beach litter at 1000 hours on 2 February 1974 by Mr. Dennis L. Bostic.

Paratypes.—BYU 42355 and BYU 42356, both adult males taken approximately 1.5 km west of town in a large arroyo on the southern end of Cedros Island on 3–4 July 1978 respectively by Mr. Michael D. Mahlstedt and myself.

Diagnosis.—A subspecies of *Lichanura trivirgata* that is distinguished from the nominate subspecies in having narrower longitudinal stripes which are black, rather than the typical brown; a darker ground color being yellowish in juveniles to a pale brownish in adults, rather than the usual cream color; and a yellowish ventrum with more numerous black blotches and stipling. It is further differentiated from *t. trivirgata* as well as *r. roseofusca* and *r. gracia* in that the ventral edges of the dorsolateral stripes are separated from the ventrum by 10 or more scale rows; *t. trivirgata* and *r. gracia* have seven to nine rows of separation. The irregular stripes of *r. roseofusca* may nearly reach the ventral scutes (specimens designated as *r. gracia* from the central portion of Baja California del Norte may be intergrades between *r. roseofusca* and *t. trivirgata* and closely approximate *t. bostici* in scutellation and dorsal pattern).

Lichanura trivirgata bostici closely approximates *t. trivirgata* in most scale characters; however, means for labials and subcaudals are high, being closer to those set for *r. roseofusca* and *r. gracia* (Tables 1 and 2).

---

[1] Life Science Museum, Brigham Young University, Provo, Utah 84602.

TABLE 1. Scale and pattern characters for mainland *Lichanura*.

	L. trivirgata	
	Gorman[1] Cape region	Klauber[2] Cape region
Dorsals	39.2(36-41)10	41.4(40-43)7
Ventrals	218.5(219-223)10	222.0(218-227)7
Caudals	45.0(42-49)10	44.0(42-46)7
Oculars	10.1(9-11)10	9.7(9-11)9
Supralabials	12.8(12-14)10	12.8(12-13)7
Infralabials	13.8(13-15)10	13.8(13-15)7
Scales between dorsolateral stripes and ventrals	8.4(7.5-9.5)8	
Dorsal stripe width	4.75(4-5)8	
Dorsolateral stripe width	5.25(5-6)8	

[1] Data from Gorman (1965).
[2] Data from Klauber (1931).
[3] Includes data from Bostic (1971).

DESCRIPTION OF HOLOTYPE.—An adult male, total length 597 mm, tail 96 mm, head length 21 mm, head width 12 mm; ratio of tail into total length 6.2, head into total length 28.4, head into body length 23.8. Dorsal scale rows on body 39-39-27, at center of tail 17; ventrals 216, subcaudals 47, anal entire; supralabials 14-15, number of elongate supralabials 2-2, infralabials 15-15, the first pair meeting at the midline; oculars 10-10; supraloreals 3-3, infraloreals 4-4; intersupraoculars 5.

Top of head is nearly flat, covered with small smooth scales. Rostral pentagonal, slightly wider (3.0 mm) than high (2.7 mm) and recurved. Nasals are divided; prenasals curving over snout to meet on the median line.

Dorsal pattern consists of three longitudinal stripes, one middorsal that is four scale rows wide and a dorsolateral stripe on each side being three to four scale rows wide at midbody. Interspaces are three to four scale rows wide between the longitudinal stripes along the body. Stripes are irregular on the head. The middorsal stripe begins on the rostum and disappears on the last quarter of the tail; the dorsolateral stripes begin at the nasals, pass through the eyes, terminating at the tip of the tail. Stripe color is black and that of the interspaces is buffy brown with occasional tiny black flecks at the bases of scales. The stripes have slightly serrated edges often bisecting a scale which presents a rather even edge. Ten scale rows separate the ventral edge of the dorsolateral stripes from the ventrals.

The ventrum is pale ochraceous-salmon with a generous amount of black blotches and stipling. The upper portions of the supralabials have minute black patches; infralabials are similarly marked along the edge of the mouth. The chin and gular region is yellowish and nearly without stipling. The eyes are light brown and have vertical pupils. The tongue is black with a white fork.

RANGE.—Known only from Cedros Island, on the Pacific coast of Baja California del Norte, Mexico.

GENERAL DESCRIPTION.—In general appearance *t. bostici* is darker than *t. trivirgata*. Two adult male paratypes BYU 42355 (total length 695; tail length 103) and BYU 42356 (total length 580; tail length 62) from the southern end of Cedros Island have the same basic characters of the type; however, BYU 42355 has extremely heavy black mottling on the ventrum (see Table 1 for scale counts). A juvenile male specimen[2] from the type locality differs in that the interspaces between the longitudinal stripes are buckthorn brown and the ventrum is more yellowish than in adults.

REMARKS.—Insular *Lichanura* was first reported by Van Denburgh (1922:633) from a single dried specimen collected by Mr. J. R. Slevin on Mejía Island in the Gulf of California. Cliff (1954:70) provided additional information stating that it had been found

---

[2] This specimen, known as DLB 3327, collected with the type by Mr. Bostic, has apparently been lost; characters were taken from this specimen while living.

L. roseofusca				
San Ignacio[1]	Arizona-Sonora[1]	*roseofusca*[2]	*gracia*[2]	*L. r. gracia*[3] from Central Desert
40	39.2(37-42)16	40.0(35-43)38	41.3(40-43)9	41.2(39-42)10
224	218.2(211-228)16	232.0(221-224)38	230.0(220-236)9	224.3(215-231)10
44	45.8(42-48)16	47.0(39-51)38	46.0(42-49)9	46.25(43-48)10
10	11.0(9-12)16	9.1(7-10)38	9.8(8-11)9	10.2(10-11)10
12.5	14.3(13-15)16	14.1(12-15)38	14.1(13-15)9	14.35(13-15)10
12-13	14.8(13-16)16	15.0(13-17)38	15.4(14-17)9	15.25(14-16)10
–	8.2(7.5-9)13	–	7.5(7-9)6	9.4(8-11)15
–	5.0(4.5-5.5)13	–	5.2(5-6)6	4.5(4-5)15
–	5.8(5-7)13	–	6.5(7-9)6	5.4(4-7)15

under a rock on 28 June 1921 and determined it to be *Lichanura roseofusca gracia* because the even-edged, red-brown, longitudinal stripe is present. In spite of numerous expeditions, the genus was not taken from another island until March 1962. These specimens, as reported by Gorman (1965) and Soulé and Sloan (1966:144), are *t. gracia* (SDSNH 51999) from Ángel de la Guarda Island and *t. trivirgata* from Tiburon Island (SDSNH (52898) and San Marcos Island (SDSNH 44389), all located in the northern portion of the Gulf of California. Powers and Banta (1976) reported a single specimen (R2002 NHSM) of *t. trivirgata* from Cerralvo Island, the first record of the genus from the southern Gulf of California island.

Lichanura t. trivirgata has been recorded by Bostic (1973, checklist) from Natividad Island, several kilometers north by northwest of Punta Eugenia and 21 km south of Cedros Island on the Pacific coast of Baja California del Norte. I have not seen a specimen and I am not aware of any new specimens in collections; therefore its occurrence can only be a tentative claim at this time.

Although Gorman (1965) followed Klauber (1931:309) and showed that insufficient evidence existed to unite *roseofusca* and *trivirgata*, Soulé and Sloan (1966) classified their specimens as different races of the species *trivirgata*. Bostic (1971:257), however, demonstrated that a basis for uniting the two species is lacking due to the absence of obvious intergrades.

Some of the data presented by Gorman (1965) and Soulé and Sloan (1966) are in conflict. Each has given different counts for ventrals and subcaudals for the specimen from Tiburon Island (SDSNH 52898) and for ventrals for the San Marcos Island specimen (SDSNH 44389). Powers and Banta (1976, Table 1) further confuse the issue by creating three specimens from the only example known from Tiburon Island (SDSNH 52898). They presented the two conflicting scale counts given by Gorman and by Soulé and Sloan as two different specimens and have included the counts of Soulé and Sloan from the San Marcos specimen (SDSNH 44389) as a third. They have also indicated Gorman (1965) as the source for scale counts given by Soulé and Sloan (1966) for the San Marcos Island specimen (SDSNH 44389). Corrected counts are presented in Table 2.

GENERAL HABITAT RELATIONSHIPS.—Savage (1967) stated that the climate of Cedros Island is milder and more moist than the immediately adjacent mainland areas (Central and Viscaino deserts), and that most of the island is covered with a desert scrub vegetation. A closed-cone pine association mixed with chaparral occurs at higher elevations. Three endemic species and endemic subspecies of the three additional species (*Gerrhonotus cedroensis, Phrynosoma cerroense, Crotalus exsul*; and *Crotaphytus wislizeni neseotes, Pituophis melanoleucus insulanus,* and *Hypsiglena torguata baueri*) are restricted to Cedros Island in addition to *L. t. bostici.*

Savage (1967) also discusses at length the herpetological distribution and population of the Pacific islands. He (1967:225) mentions evidence presented by Muller and Axelrod (in symposium) demonstrating that many islands appear to be refugia of relicts. In discussing relict populations, comparisons between species of the lizard genus *Anniella* indicate that *A. geronimensis* is being replaced by *A. pulchra* on the mainland, which may eventually lead *A. geronomensis* to become an insular relict.

The habitat of the lower arroyos and the climate of Cedros Island are somewhat similar to the Punta Eugenia-Sierra Viscaino region, particularly along the coast line. This evidence suggests that *Lichanura trivirgata bostici* may have experienced or may still be experiencing a competitive pressure from the mainland *L. t. trivirgata* similar to that being presently expressed in *Anniella*.

The habitat of Cedros Island appears to be more typical of areas where *L. roseofusca* gracia may be found. On the basis of evidence presented, a race closely allied to *L. trivirgata* is existing under conditions more typical to *L. roseofusca*.

At present the closest known locality of *L. trivirgata* to Cedros Island is just west of San Ignacio; however, more intensive collecting toward the Punta Eugenia-Sierra Viscaino region may produce specimens. The closest known locality for *L. roseofusca* lies just north of San Javier (Bostic 1971:257) in Baja California del Norte. If *L. trivirgata* reaches Punta Eugenia, the species would be less than 40 km from Cedros Island, having Natividad Island midway between these points.

ACKNOWLEDGMENTS

Field work was partially supported by the Associated Students of Brigham Young University Student Research Fund. I wish to thank Dr. Wilmer W. Tanner, Dr. Kent Van de Graff, and Dr. Douglas C. Cox for their constructive reviews of this paper. Dr. Thomas Fritts of the San Diego Society of Natural History and Mr. James Hudnall and Dr. Charles Lowe, Jr., of the University of Arizona, Tucson, were kind enough to loan specimens. For untiring assistance in the field, my appreciation is extended to Sr. Antonio Beltrán, Mr. John C. Cram, Mr. Michael D. Mahlstedt, Mr. Robert W. Murphy, and Miss Jan G. Sprague. Dr. Miguel Villarino Santana of the Centro de Salud, Sr. Borrego, and Sr. Beltrán and family extended us a welcomed hospitality while on Cedros Island. Capitán Morales of Guerrero Negro provided efficient air transportation to and from the island. Mrs. Vickie R. Ottley and Mrs. Gail Olsen typed the manuscript. Mr. Brian Hatch prepared the photographs for Figures 1 and 2. The Scientific Collecting Permit was provided by Dr. Antonio Landazuri O., Director General, Fauna Silvestre Depto. de Conservacion, Mexico, D. F. Mrs. Lorie Burningham helped prepare Tables 1 and 2.

TABLE 2. Scale and pattern characters for insular *Lichanura*.

	L. r. gracia	*L. trivirgata*			*L. trivirgata bostici*					
	Ángel de la Guarda	Tiburon[1]	San Marcos[1]	Cerralvo[2]	BYU 41385	BYU 42355	BYU 42356[3]	DLB 3327	No. of specimens	Mean
Dorsals	41	40	40	39	39	41	40	41	4	40.25
Ventrals	235	222	224	219	216	223	219	218	4	219
Caudals	49	43	41	40	47	47	30	45	3	46.3
Oculars	11-11	10-11	10-10	10-10	10-10	10-10	10-10	11-11	4	10.25
Supralabials	14-14	15-15	15-15	13-13	14-15	15-14	14-15	15-15	4	14.6
Infralabials	16-15	15-15	16-15	14-13	15-15	13-14	14-15	14-14	4	14.25
Scales between dorsolateral stripes and ventrals	9	9	8	9	10	10.5	10	–	3	10.2
Dorsal stripe width	4	4	6	4.5	4.0	4.0	4.5	–	3	4.2
Dorsolateral stripe width	4.5	4.5	6	5.5	4.0	4.0	3.5	–	3	3.8

[1] Corrected scale counts for SDSNH 44389 and SDSNH 52898.

[2] Corrected scale counts for R2002 NHSM.

[3] Tail incomplete.

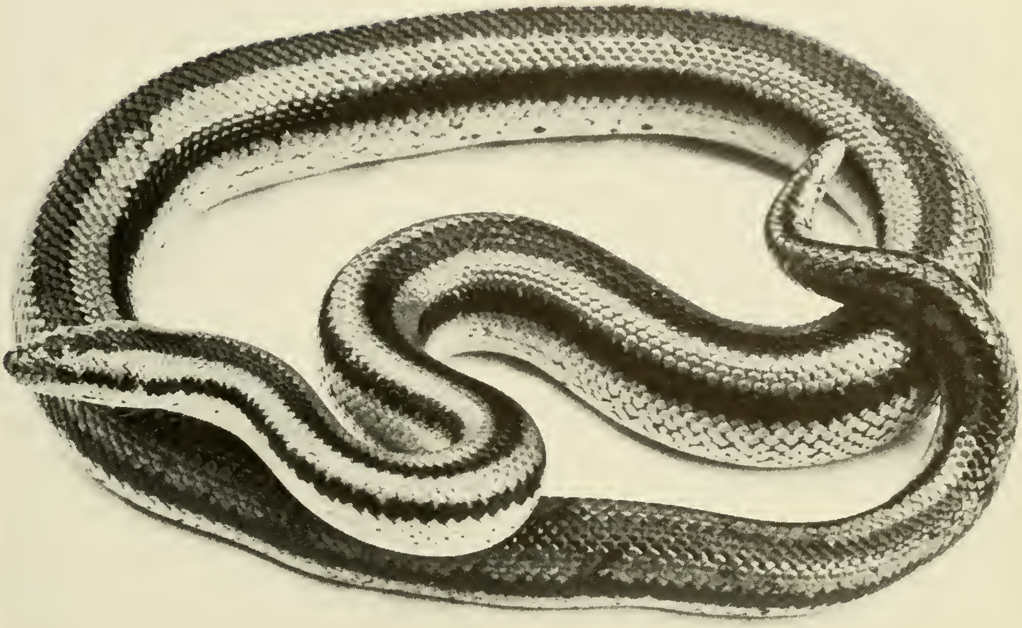


Fig. 1. Dorsal view of *Lichanura trivirgata bostici*, BYU 42355 (paratype), collected on the southern end of Cedros Island, 3 July 1978.

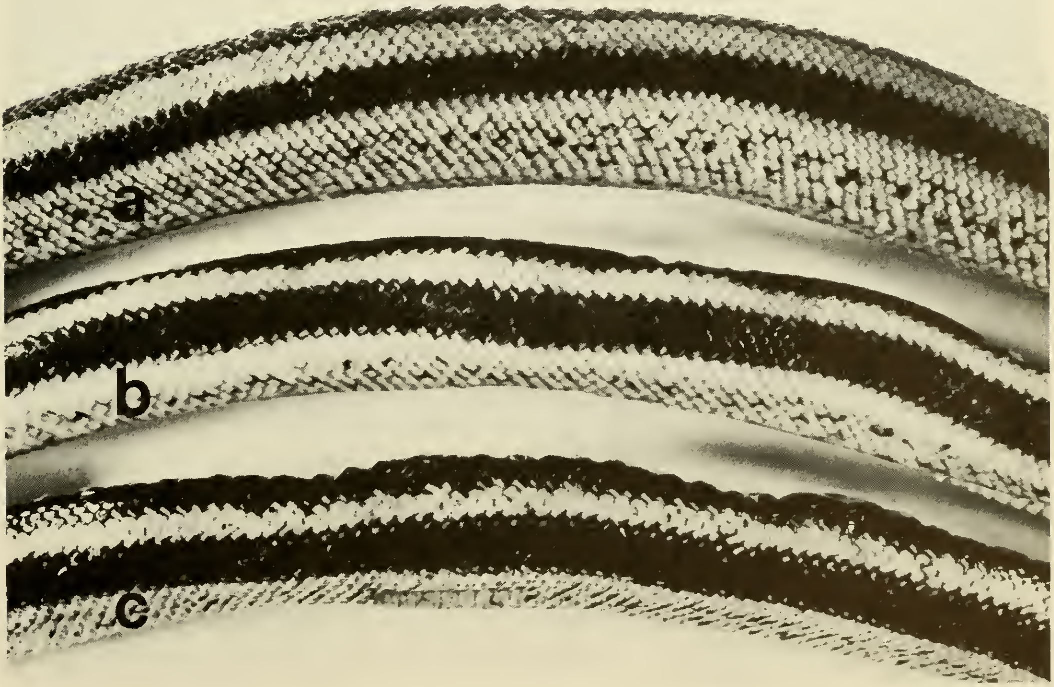


Fig. 2. Lateral view showing the narrower and higher dorsolateral stripe of (a) the holotype, compared with (b and c) specimens of *Lichanura t. trivirgata* from Baja California del Sur.

LITERATURE CITED

BOSTIC, D. L. 1971. Herpetofauna of the Pacific Coast of north central Baja California, Mexico, with a description of a new subspecies of *Phyllodactylus xanti*. Trans. San Diego Soc. Nat. His. 16(10):237-263.

______. 1973. Natural history guide to the Pacific Coast of north central Baja California and adjacent islands. Pub. Biological Education Expeditions, Inc., San Diego, California. 80 pp.

CLIFF, F. S. 1954. Snakes of the islands in the Gulf of California, Mexico. Trans. San Diego Soc. Nat. His. 12(5):69-97.

GORMAN, G. C. 1965. The distribution of *Lichanura trivirgata* and the status of the species. Herpetologica 21(4):283-287.

KLAUBER, L. M. 1931. A new subspecies of the California Boa, with notes on the genus *Lichanura*. Trans. San Diego Soc. Nat. His. 6(20):305-318.

______. 1933. Notes on *Lichanura*. Copeia (4):214-215.

MURRAY, K. F. 1955. Herpetological collections from Baja California. Herpetologica 11(1):33-48.

POWERS, A. AND BANTA, B. H. 1976. *Lichanura trivirgata* Cope recorded from Cerralvo Island, Gulf of California Mexico. Bull. Maryland Herp. Soc. Vol. 12. no. 4:119-121.

RIDGEWAY, R. 1912. Color standards and color nomenclature. Washington, D.C., 43 pp., 53 pls.

SAVAGE, J. M. 1967. Evolution of the insular herpetofaunas. Proceedings of the Symposium on the Biology of the California Islands. Santa Barbara Botanic Gardens, pp. 219-227.

SOULÉ, M., AND A. J. SLOAN. 1966. Biogeography and distribution of the reptiles and amphibians on islands in the Gulf of California, Mexico. Trans. San Diego Soc. Nat. His. 14(11):137-156.

VAN DENBURGH, J. 1922. The reptiles of western North America. Occ. Pap. Calif. Acad. Sci. 2(10):1-1028.

VERTICAL DISTRIBUTION OF ADULT FISH IN PYRAMID LAKE, NEVADA[1]

Steven Vigg[2]

ABSTRACT.— Inshore and limnetic vertical distribution of adult fish in Pyramid Lake, Nevada was determined from late spring to early fall 1977. The benthic (23 m) inshore area exhibited a relatively diverse composition of five species, while the inshore surface and offshore limnetic zones were composed of over 98 percent tui chubs (*Gila bicolor*). Vertical fish distribution was associated with temperature and zooplankton distribution.

Prior to the Pyramid Lake Ecological Study, 1975–1978, limited data were available on the relative abundance, distribution, and environmental relationships of Pyramid Lake fish populations. Historically, Snyder (1917) made observations on the life histories, seasonal movements, and spawning migrations of fishes occurring in the lake. Sumner (1938, 1939) documented the decline of the Lahontan cutthroat trout, *Salmo clarki henshawi*, and related factors responsible for the ultimate extinction of the pure Pyramid Lake strain. After successful reintroduction of salmonids into Pyramid Lake in the early 1950s the Nevada Fish and Game Department conducted life history investigations of the fish species during 1954–58, including limited population inventory (Johnson 1958). Koch (1972, 1973) studied the ecology and reproductive characteristics of the endangered, endemic cui-ui, *Chasmistes cujus*, with reference to environmental conditions that may become limiting to this species. During recent years, the United States Fish and Wildlife Service has been monitoring cui-ui population trends in the vicinity of the Truckee River delta and spawning runs of Lahontan cutthroat trout through the Marble Bluff fish passage facility.

Conflicts over water resource utilization of the Truckee River-Pyramid Lake ecosystem have indicated a need for a reliable assessment of its fishery resource. Distribution and abundance data on the fish populations of Pyramid Lake in relation to environmental conditions are essential to such an assessment. With adequate data on the ecosystem dynamics of Pyramid Lake, an understanding of the effects of potential changes in environmental conditions on the lake's fish populations may be achieved.

The purpose of this research was to describe the vertical distribution of fish in Pyramid Lake. Secondarily, relationships between spatial fish distribution, and temperature and zooplankton distribution are presented.

STUDY AREA

Pyramid Lake is the deepest remnant of Pleistocene Lake Lahontan, which once occupied an area of 5,006,490 ha from west-central Nevada, north to the Oregon border (Russell 1885). Pyramid Lake is approximately 40 km long and 6.5 to 16 km wide. The upper two-thirds of the lake has an oval shape and a north-south axis, while the relatively narrow and shallow lower third is rectangular with a southeasterly axis. At the mean 1976 elevation of 1,157.3 m (United States Geological Survey 1977), the lake had a surface area of 44,637 ha, volume of $2.638 \times 10^{10} m^3$, mean depth of 59 m, and maximum depth of 103 m (Harris 1970).

---

[1] The Pyramid Lake ecological study was conducted by W. F. Sigler & Associates, Inc., under contract (#H50C14209487) to the United States Department of Interior, Bureau of Indian Affairs.

[2] W. F. Sigler & Associates, Inc., 1005 Terminal Way, Suite 155, Reno, Nevada 89502.

Being the terminal water body of the endorheic Truckee River system, the only outflow from Pyramid Lake is by evaporation. Due to water diversions from the Truckee River, the water level of Pyramid Lake has declined 22 m since 1909. At present the lake water is highly ionic, being saline, alkaline, and basic (pH = 9.2). The 1976 total dissolved solids (TDS) concentration of 5,235 mg/l was composed of 68 percent sodium chloride (Edward L. Lider, pers. comm.). The lake may be considered eutrophic because it supports large plankton and fish populations.

Water temperature seasonally ranges from 0.6 to 25.5 C (Koch 1973). As winds subside and surface water temperature increases, a thermocline develops during June and persists through December. Following physical destratification, the turnover begins in early winter and mixing extends to spring. Pyramid Lake is thus classified as monomictic (Hutchinson 1957).

Procedures

Surface and bottom gill nets were fished along the 23 m depth contour on the east and west sides of the north, middle, and south sections of Pyramid Lake. Concurrently, gangs of vertical gill nets were fished in the center of Pyramid Lake, in the deepest area (90 m+). Thus, six inshore surface-bottom stations (stratified by lake area) and one limnetic water column station were sampled on a monthly basis (Fig. 1).

Surface-bottom gill nets were test-fished from February through May 1977 (12 samples), and intensively fished from June through November 1977. During this period, 35 surface samples above the thermocline and 35 bottom samples below the thermocline, at a depth of 23 m, were taken.

The bottom gill nets were 1.83 m deep and 76.20 m in length. The nets were composed of ten 1.83 × 7.62 m panels of the following mesh sizes (cm bar measure): 1.27, 1.91, 2.54, 3.18, 3.81, 4.45, 5.08, 6.35, 7.62, and 8.89. The 76.20 m surface gill nets were identical to the bottom-set nets except they were 3.66 m instead of 1.83 m deep and rigged to float on the surface instead of sinking to the bottom.

Vertical gill nets (four mesh sizes) were test-fished in offshore areas from December 1975 through February 1976; however, bad weather made the sampling inefficient and the catch rate was very low, apparently due to the large mesh sizes used. I implemented an intensive vertical gill netting program from June through October 1977. A total of 18 sets of gangs of eight graduated mesh sizes were made at the midlake limnetic station during this period, on a monthly basis.

The vertical gill nets were similar to those described by Horak and Tanner (1964). The nets were anchored at a bottom depth of over 90 m, and extended from the surface to about 46 m. Spreader bars physically separated each net into six 7.62 m depth increments. The nets, 2.44 × 45.72 m, were set in gangs of eight nets of the following mesh sizes (cm bar measure): 1.27, 1.91, 2.54, 3.81, 5.08, 6.35, 7.62, and 8.89.

All nets were built of white multifilament nylon. The thread diameters (for respective mesh sizes) were 0.23 mm (1.27 cm), 0.28 mm (1.91 and 2.54 cm), 0.33 mm (3.18, 3.81, 4.45, 5.08, and 6.35 cm), and 0.40 mm (7.62 and 8.89 cm).

Distribution was evaluated with respect to catch/effort. The unit-of-effort was defined as a one-day (approximately 24 hours) gill net set.

Results and Discussion

The benthic (23 m) inshore area exhibited a relatively diverse species composition: tui chub (*Gila bicolor*), Tahoe sucker (*Catostomus tahoensis*), Lahontan cutthroat trout, cui-ui, and Sacramento perch (*Archoplites interruptus*). In contrast, Tahoe suckers, cui-ui, and Sacramento perch were rare in the inshore surface waters and absent in the limnetic zone. Over 98 percent of the catch in the surface-inshore and limnetic zones were composed of tui chubs; the remainder was primarily Lahontan cutthroat trout.

Tahoe suckers were almost entirely benthic in habitat; 99.7 percent of the catch at 23 m was taken on the bottom (Table 1). McConnell et al. (1957) found the Utah

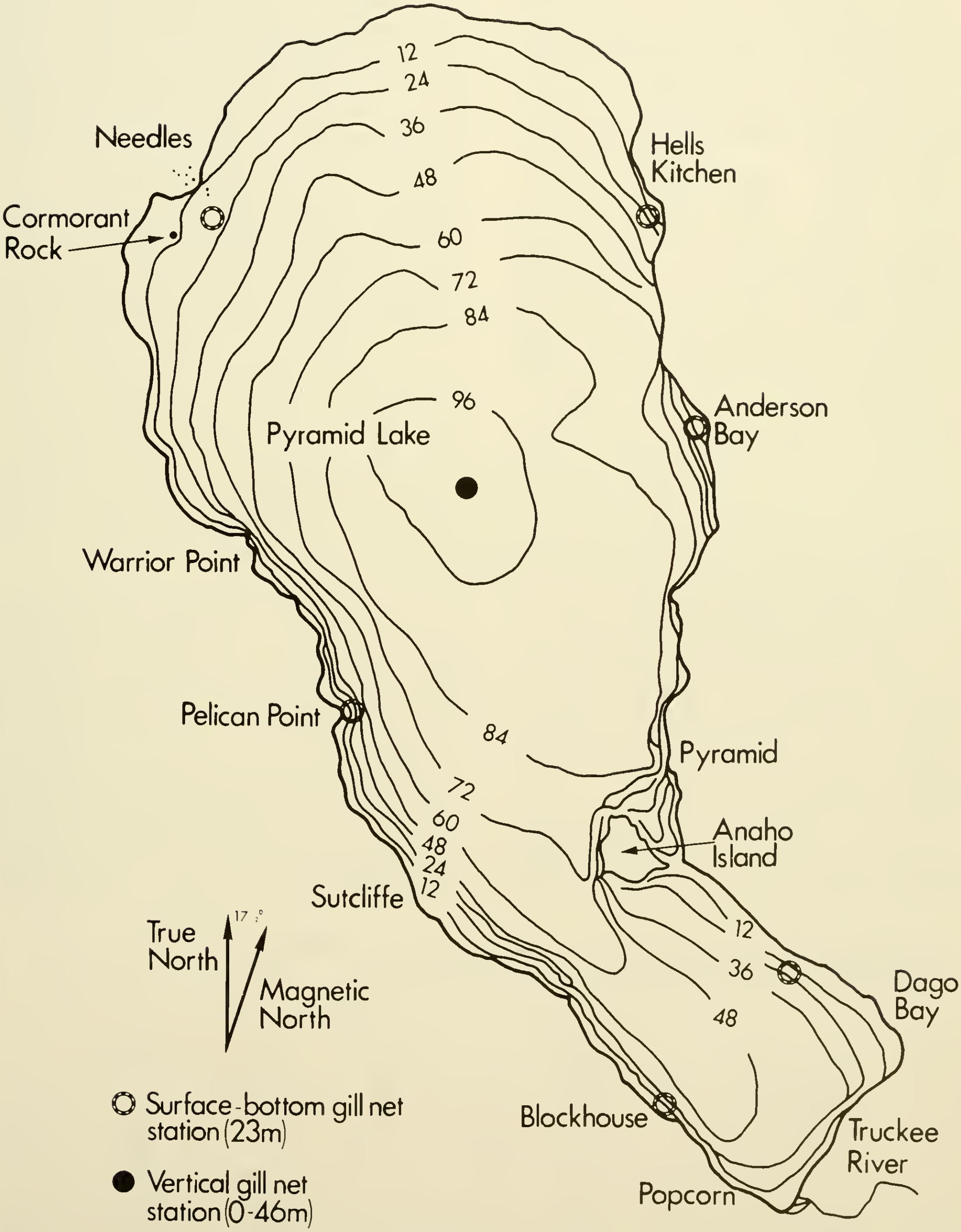

12
24
36
48
60
72
84
96
Needles
Cormorant Rock
Hells Kitchen
Anderson Bay
Pyramid Lake
Warrior Point
Pelican Point
84
72
60
48
24
12
Sutcliffe
Pyramid
Anaho Island
12
36
48
Dago Bay
True North
17
Magnetic North
Blockhouse
Truckee River
Popcorn
○ Surface-bottom gill net station (23m)
● Vertical gill net station (0-46m)

Fig. 1. Gill net sampling stations (six inshore and one limnetic) in Pyramid Lake, Nevada.

sucker, *Catostomus ardens*, exclusively on the bottom of Bear Lake, concentrated at depths of 7.5–23 m. This benthic behavioral preference is characteristic of the genus *Catostomus*. These suckers exhibit extreme specialization and orientation of the jaws, general morphological adaptations (inferior mouth, numerous papillae and taste buds, limited eyesight, and position of eyes in the head), and behavioral modifications for suctoral feeding (Martin 1972); all of these adaptations are indicative of obligatory bottom dwellers.

The cui-ui is a lacustrine sucker (Catostomidae), endemic to Pyramid Lake. The diet of this species consists almost exclusively of zooplankton (Johnson 1958, LaRivers 1962); and it has therefore been hypothesized that cui-ui inhabit open limnetic waters where zooplankton are abundant (LaRivers 1962). My findings indicate, however, that cui-ui are inshore oriented—they were never captured in the midlake limnetic area. Cui-ui were concentrated in the littoral zone (0–15 m) and were never taken in benthic areas deeper than 46 m (Vigg 1978a). Cui-ui were infrequently captured at 23 m, either on the surface or bottom. The only surface catch occurred during spring corresponding to their spawning season; the maximum benthic catch of cui-ui at 23 m occurred during fall as surface water temperatures were decreasing. The catch rate of Sacramento Perch at 23 m was extremely low (mean of 0.06/net), however the seasonal pattern was similar to that of the cui-ui.

Cutthroat trout and tui chub exhibited temporal changes in vertical inshore distribution which were associated with surface water temperature (Fig. 2). The maximum surface distribution of cutthroat trout occurred during April and May. When the surface water temperature increased from the May level of 10.3 to 16.3 C in June the cutthroat trout moved almost entirely out of the surface waters (less than 5 percent of the catches were taken in the surface nets). The lowest seasonal density of cutthroat trout occurred in surface waters (0.68/net), and the highest density occurred in benthic waters below the thermocline (8.42/net) during the summer period. As surface waters cooled from 16.5 C in October to 14.5 C in November, the proportion of cutthroat trout captured on the surface began to increase. Judging from the December temperature of about 11 C, the proportion of the cutthroat trout population inhabiting surface waters probably continued to increase during early winter. This distribution pattern indicates that the Lahontan cutthroat trout are predominantly benthic in their distribution throughout the year, but they prefer areas exhibiting the temperature range of 7–15 C in Pyramid Lake under natural conditions.

The cutthroat trout catch offshore in the limnetic zone was relatively low and exhibited substantial vertical dispersion (Table 2). About 69 percent of the total catch from June through October was taken at depths of 15 to 37.5 m, at temperature ranges of 11.2–18.5 C and 7.5–8.1 C, respectively. During the entire period, the 37.5–45.0 m depth stratum (at temperatures <7.5 C) exhibited the lowest trout catches. No trout were captured in the upper 7.5 m during

Table 1. Fish catch in the surface (3.66 × 76.2 m gill net) and bottom (1.82 × 76.2 m gill net) zones at the 23 m depth contour of Pyramid Lake, from June through November 1977.

		Species					
Depth zone	Catch statistic	Cutthroat trout	Cui-ui	Tahoe sucker	Tui chub	Sacramento perch	Total
Surface	Number	47	0	2	2,657	1	2,707
	Catch/net	1.34	0	0.06	75.91	0.03	77.34
	Percent by species	1.7	0	0.07	98.2	0.04	100
	Percent by depth	14.8	0	0.03	57.4	25.0	48.4
Bottom	Number	270	10	631	1,975	3	2,899
	Catch/net	7.71	0.29	18.03	56.43	0.09	82.54
	Percent by species	9.3	0.4	21.8	68.4	0.1	100
	Percent by depth	85.2	100	99.7	42.6	75.0	51.6

July and August, at temperatures ranging 20.6–23.2 C.

Temperature is generally considered the major directive influence on vertical fish distribution in lakes; dissolved oxygen is a secondary effect, restricting fish distribution where anaerobic conditions occur (Dendy 1948, Borges 1950, Ferguson 1958, Horak and Tanner 1964, von Geldern 1964, May 1973, Gebhart and Summerfelt 1975, and Lindenberg 1976). In Walker Lake, Nevada, high surface water temperatures interact with hypolimnetic oxygen deficits during summer to restrict cutthroat trout to a narrow zone in the vicinity of the thermocline (Cooper 1978). In Pyramid Lake, however, I found low dissolved oxygen concentrations to restrict fish distribution only in the profundal zone during late fall prior to lake mixing (Vigg 1978a).

Horak and Tanner (1964), and von Geldern (1964) found the majority of rainbow trout (*Salmo gairdneri*) distributed in depth intervals exhibiting the temperature range 15.5–21.0 C. Fast (1973) and Overholtz et al. (1977) also found rainbow trout dis-

Table 2. Catch of cutthroat trout and tui chub in depth strata of the limnetic zone of Pyramid Lake, from June through October 1977.

Depth interval (m)	Cutthroat trout		Tui chub	
	Number	Percent	Number	Percent
0–7.5	5	14.3	1,962	37.5
7.5–15	5	14.3	1,900	36.4
15–22.5	9	25.7	935	17.9
22.5–30	6	17.1	232	4.4
30–37.5	9	25.7	195	3.7
37.5–45	1	2.9	3	0.05
TOTAL	35	100	5,227	100

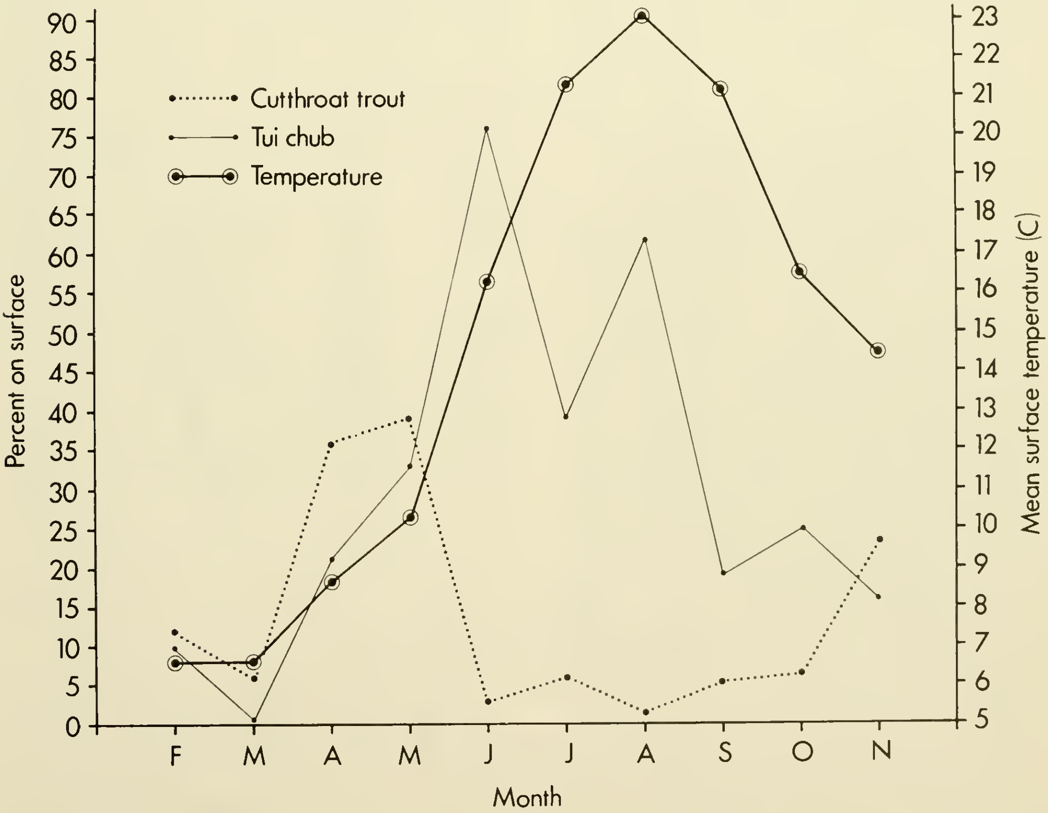


Fig. 2. Percent of the catches of cutthroat trout and tui chub taken on the surface; from surface and bottom gill nets (adjusted to unit of net area) at the 23 m depth in Pyramid Lake from February through November 1977.

tributed in vertical strata exhibiting temperatures less than 21.0 C. The preferred temperature and associated depth distribution is species-specific; e.g., kokanee (*Oncorhynchus nerka*) were primarily found at temperatures of 10.5–15.5 C (Horak and Tanner 1964). The vertical distribution of cutthroat trout in a large Montana reservoir indicated that their preferred temperature was in the 15–17 C range (Steven L. McMullin, letter dated 30 September 1977). This observation is in accord with Dwyer and Kramer's (1975) findings that the scope for activity of cutthroat trout was maximum at 15 C.

The fact that I observed maximum cutthroat trout densities in vertical strata exhibiting relatively low temperature ranges may be attributed to a lower temperature preference of the Lahontan cutthroat subspecies, or synergestic interaction between temperature and the high alkalinity levels of Pyramid Lake. Preliminary evidence indicates that as alkalinity concentration increases from the level of fresh water (<100 mg/l) to Pyramid Lake water (>1400 mg/l), the lethal temperature range is considerably lowered (Vigg and Koch 1978).

The periods of maximum surface orientation of the cutthroat trout population corresponded to the spawning run at the Marble Bluff fishway (April-May) and the maximum activity of the trout in the lake (December) (Vigg 1978b). The temperature regime of the surface waters functions as a gateway, allowing access from the hypolimnion of the lake through the shoals and into the Truckee River. This "gateway" is open during spring and again in early winter; interacting with river flows and temperatures, the lake's temperature mechanism thus delimits the potential spawning periods of the cutthroat trout population. Snyder (1917) documented that historical spawning runs of Pyramid Lake Lahontan cutthroat trout originally occurred both in early winter and spring.

The response of tui chubs to the temperature regime was nearly opposite that of cutthroat trout. The proportion of the tui chub catch taken in the surface waters was directly related to temperature from February through June; as temperature increased from 6.6 to 16.3 C, the proportion of the catch/effort per unit of net area taken on the surface increased from less than 10 percent to over 75 percent. The mean proportion on the surface during July and August was about 51 percent, at surface temperatures of about 22 C. Temperatures declined from 21.2 C in September to 14.5 C in November; during this period the percent of tui chubs taken in the surface samples had decreased to about 20 percent. This movement of tui chubs from surface to benthic areas during fall is consistent with previously documented onshore-offshore benthic distribution patterns (Vigg 1978a). For example, during August 1977, 95 percent of the tui chub catch was taken in littoral (0–15 m) areas; by November, 64 percent was taken offshore at 46 m.

Similar *Gila* distribution patterns have been observed by other workers. Snyder (1917) reported an inshore movement of tui chub in Pyramid Lake in late May, associated with warm water temperatures and commencement of spawning. The Eagle Lake tui chub population also shifted in the spring from the deep waters inhabited during the winter into warming shallow waters (Kimsey 1954). The limnetic form of Lake Tahoe tui chub inhabits upper waters during the summer and disappears into deep water during the winter; the benthic form likewise inhabits deep water during the winter, but shallow littoral areas during the summer (Miller 1951). Gaufin (1964) observed that Utah chubs, *Gila atraria*, generally concentrated in the warmest areas of Fish Lake. Food consumption and assimilation, growth, and metabolic rates of Utah chub are directly related to temperature and are highest at 20 C (Cheng 1975). The Utah chub in Hebgen Lake, Montana, concentrated in shallow areas in the spring, were widely distributed in the summer and fall, and concentrated in deeper waters in winter (Graham 1961). In Flaming Gorge Reservoir, the Utah chub population moved into the littoral and eulittoral areas about a month prior to the commencement of spawning, which occurred mid-June through mid-July (Varley and Livesay 1976). This inshore movement corresponded to peak catches (activity) observed during July.

The offshore, limnetic tui chub population was surface oriented during the warm season. From June through October, about 92 percent of the limnetic tui chub catch was taken in the upper 23 m (Table 2).

Vertical limnetic distribution of tui chub is undoubtedly affected by temperature; however sampling was conducted during the warmest months of the year (June-October) when mean surface temperature ranged only 16.3–23.1 C. Therefore, all of the seasonal distribution patterns (e.g., downward winter shift) were not qualified by the vertical gill net sampling of the limnetic zone. Nonetheless, monthly changes in vertical distribution occurred within this upper temperature range. Maximum surface temperature (mean = 23.1 C) was associated with maximum occurrence (70.4 percent) of tui chub in the upper 7.5 m.

The temperature regimes in June (mean surface temperature was 16.3 and increasing) and October (mean surface temperature was 16.5 and decreasing) were similar; likewise, the vertical distribution patterns of tui chubs were similar. During June and October, 94.8 and 90.8 percent, respectively, of the total catch was taken in the upper 15 m.

July and September also exhibited similar temperature regimes (mean surface temperature was 21.25 C) and similar (dispersed) tui chub distribution patterns. The 7.2–22.5 m depth interval was most abundantly represented, 72.6 percent of the total in July and 72.1 percent in September.

The limnetic tui chub population of Pyramid Lake is composed almost exclusively of the planktiverous (fine gill rakered) *pectinifer* form which feeds almost entirely on zooplankton (Langdon 1978). The vertical distribution of limnetic tui chubs was associated with that of the zooplankton they were selecting in their diet (Fig. 3). In June,

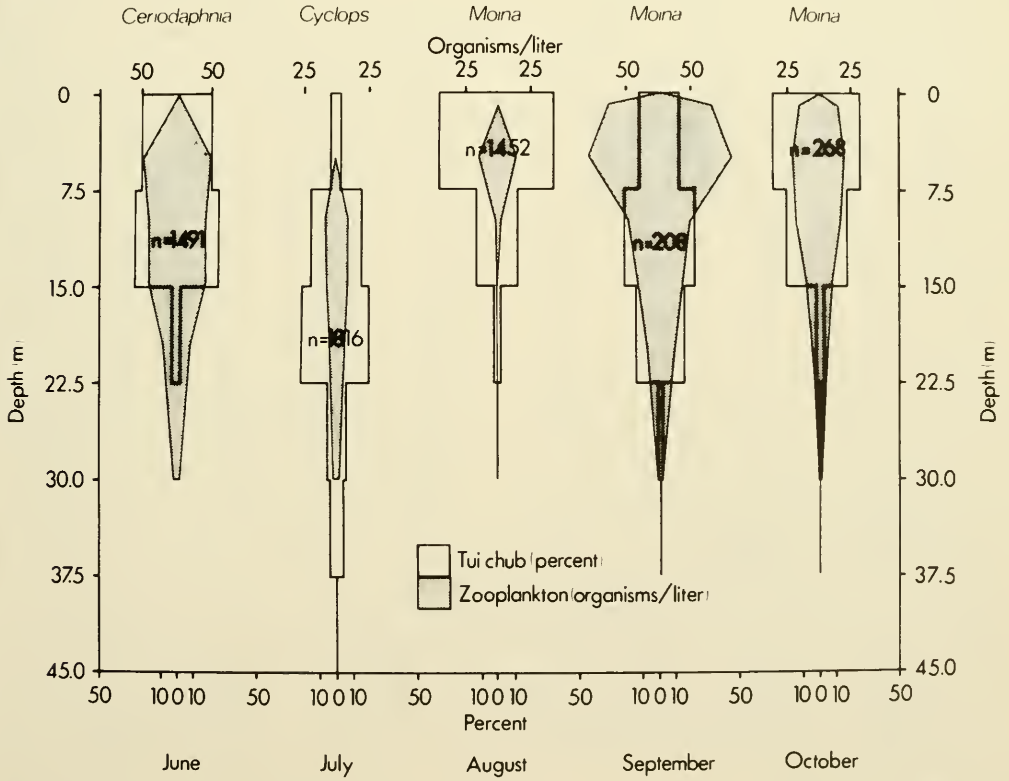


Fig. 3. Vertical limnetic distribution (percent by depth interval) of tui chub in Pyramid Lake, Nevada, from June through October 1977 in relation to the vertical distribution (density by depth interval) of the zooplankton taxon selected in the diet of tui chubs.

Ceriodaphnia quadrangula was very abundant in the upper 15 m, with decreasing density to 30 m; likewise, tui chubs were most abundantly represented in the upper 15 m, with an appreciable proportion to the 22.5 m depth. The selected zooplanker in July, *Cyclops vernalis*, was less abundant than *C. quadrangula* of the previous month; however, its absence in the surface waters and predominance in the 7.5–22.5 m depth interval mirrored the vertical distribution of the tui chub. The tremendous abundance of tui chubs in the upper 7.5 m in July may have kept the standing crop of its selected food item, *Moina hutchinsoni*, at low densities; and the vertical distributions of the fish and zooplankton were strikingly similar. During September the tui chub population was less dense (about 14 percent of the August level), and more evenly dispersed over the entire 0–22.5 m depth interval. Concurrently, *M. hutchinsoni* was very abundant in the same depth strata. *Monia hutchinsoni* populations were most dense in the surface waters; however, due to the relatively high proportion of zooplankton to fish, it is unlikely that zooplankton were restricting the distribution of tui chubs within the upper 22.5 m of the limnetic zone. Tui chub distribution shifted upwards into the 0–15 strata during October. *Monia hutchinsoni* was less abundant this month and showed a very similar distribution pattern to that of the tui chub.

The preliminary hydroacoustic survey conducted during April 1976 provided supplemental information on the vertical distribution of tui chubs. Apparently the upward vertical migration had already occurred by this early spring month; the limnetic tui chub population was concentrated in the 4–18 m strata, with appreciable densities extending to 48 m (Nunnallee et al. 1976) Concurrent total zooplankton densities exhibited a very similar vertical distribution pattern (Lider and Langdon 1978). Upward prevernal migration was substantiated by initial sightings of abundant tui chub schools on the surface in March—during weekly aerial observations, 1976–1978 (Joseph L. Kennedy, pers. comm.).

Thus, seasonal vertical migration of tui chubs are probably concurrent with inshore-offshore distribution trends already documented. In summary, it is likely that temperature-related factors are directive influences on the fish and zooplankton which interact within their predator-prey relationships to form the observed limnetic distribution patterns.

Diel activity patterns and vertical distribution was determined during June and August 1977. Sampling was conducted over continuous 24-hour periods in the vicinity of Cormorant Rock (northwest Pyramid Lake). Surface and bottom gill net samples were taken at 4-hour intervals along the 23 m depth contour; i.e., a total of 24 net sets were made.

Tui chubs were predominantly taken on the surface, and cutthroat trout were predominantly taken on the bottom at 23 m. During both June (Fig. 4) and August (Fig. 5), however, fish catches exhibited consistent distribution changes with respect to time-of-day. Tui chubs were almost exclusively taken in the surface waters from 2000-0400 hours; the surface catch was negligible during the twilight and daylight hours. This could be attributed solely to net avoidance during daylight. For example, Lindenberg (1976) attributed the absence of alewives (*Alosa pseudoharengus*) in the catch of vertical gill nets during to day to net avoidance, even though the net appeared invisible to divers in the water. However, my experience with surface gill net sampling indicates that if fish were present in appreciable numbers they would be captured. For example, I captured large numbers of suckers (*Catostomus*) and shiners (*Notemigonus*) in daytime, surface-set, white, multifilament gill nets in littoral areas of Ruth Reservoir.

I believe the observed patterns actually illustrate a movement of the tui chub population out of the surface into midwater. During both diel samples, the early morning movement of tui chubs out of surface waters corresponded to peak bottom catches at 0400-0800 hours. I think this represents an overcompensation in downward movement, which occurred when the bulk of the tui chub population moved to midwater. Similar over-compensatory vertical migrations of zooplankton after sunrise have been documented (Hutchinson 1967). The diel vertical distribution of zooplankton closely corresponded to that of tui chubs. The prey species of zooplankton were most dense in surface waters from 2000-0400 hours and least dense at 1200; during midday, the highest densities were observed at 5–10 m (Lider and Langdon 1978). Benthic densities of zooplankton were generally low during all time periods.

Very few cutthroat trout were captured

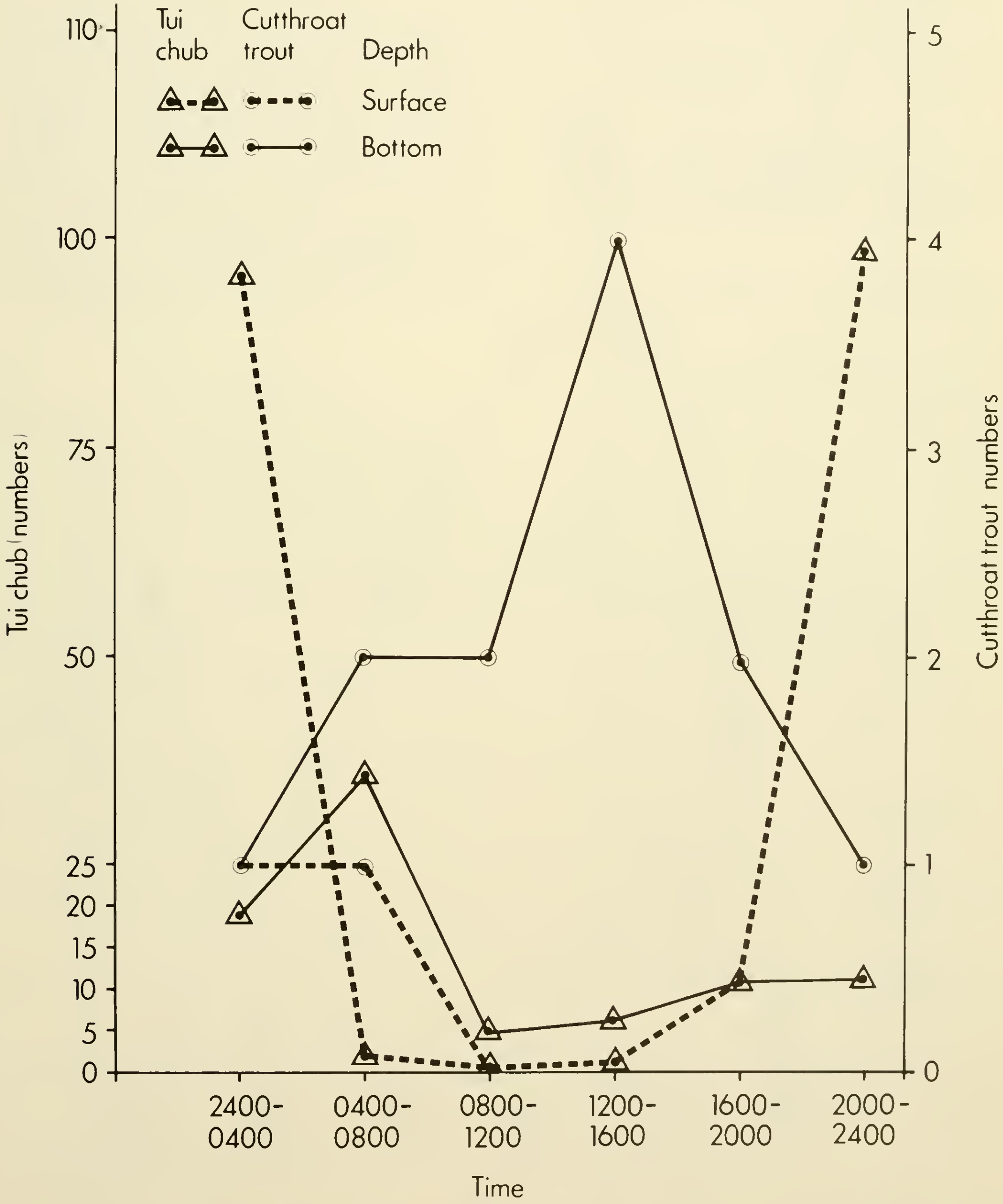


Fig. 4. Diel activity and vertical distribution patterns of tui chub and cutthroat trout at the 23 m depth in the vicinity of Cormorant Rock, Pyramid Lake, Nevada, during June 1977.

in surface nets. The morning hours (2400-1200) accounted for the entire surface trout catch. On the bottom, cutthroat trout catches were greatest during the daylight hours (0400-2000). Because trout are sight feeders, it is logical that their activity would be greatest during this time period. Although no samples were taken midwater, I hypoth-

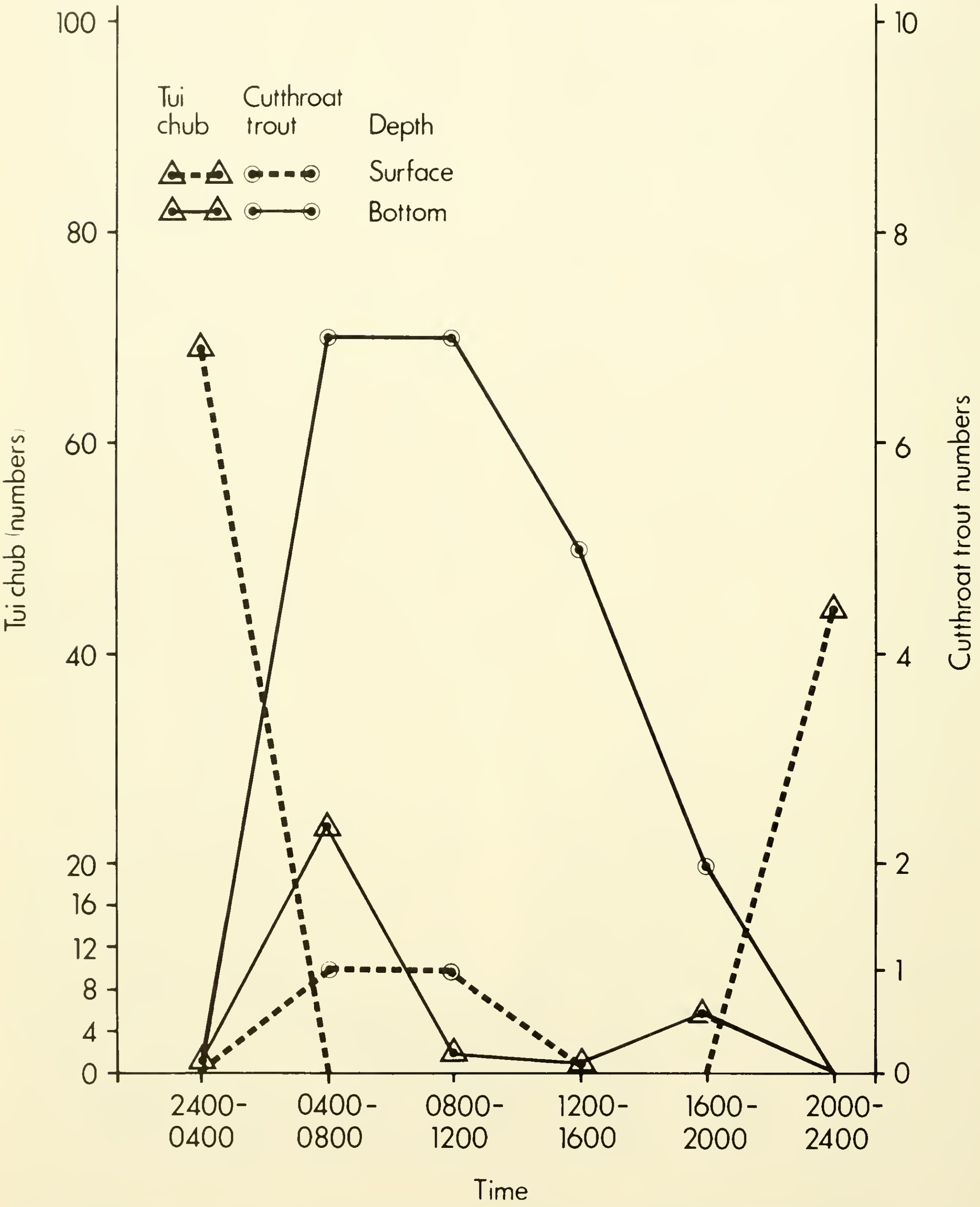


Fig. 5. Diel activity and vertical distribution patterns of the tui chub and cutthroat trout at the 23 m depth in the vicinity of Cormorant Rock, Pyramid Lake, Nevada, during August 1977.

esize that cutthroat trout moved into the midwater zone during the daylight hours to feed on the tui chub population which was concurrently at maximum densities there.

ACKNOWLEDGMENTS

The Pyramid Lake Paiute Indian Tribe was instrumental in initiating the ecological research effort on Pyramid Lake. This research was funded by the Bureau of Indian Affairs, Contract H50C14209487. Mr. Floyd (Sam) Dunn and Mr. Dale Hebel carried out a great deal of the field work during this study. Mr. Edward Lider provided information on zooplankton distribution, and Mr. Richard Langdon provided information on tui chub diet.

LITERATURE CITED

BORGES, M. H. 1950. Fish distribution studies, Niangua Arm of the Lake of the Ozarks, Missouri. J. Wildlife Management 14(1):15-33.

CHENG, F. C. 1975. Bioenergetics of Utah chub and rainbow trout. Ph.D. Dissertation. Univ. of Idaho. 69 pp.

COOPER, J. J. 1978. Contributions to the life history of the tui chub (*Gila bicolor*) in Walker Lake, Nevada. Unpublished master's thesis. Univ. of Nevada, Reno. 98 pp.

DENDY, J. S. 1948. Predicting depth distribution of fish in three TVA storage-type reservoirs. Trans. Am. Fish Soc. 75(1945):65-71.

DWYER, W. P., AND R. H. KRAMER. 1975. The influence of temperature on scope for activity in cutthroat trout, *Salmo clarki*. Trans. Am. Fish Soc. 104(3):552-554.

FAST, A. W. 1973. Effects of artificial hypolimnion aeration on rainbow trout (*Salmo gairdneri* Richardson) depth distribution. Trans. Am. Fish. Soc. 102(4):715-722.

FERGUSON, R. G. 1958. The preferred temperature of fish and their midsummer distribution in temperate lakes and streams. J. Fish. Res. Bd. Canada. 15(4):607-627.

GAUFIN, R. F. 1964. Ecology of the Utah chub in Fish Lake. Unpublished master's thesis. Univ. of Utah. 111 pp.

GEBHART, G. E. AND R. C. SUMMERFELT. 1975. Factors affecting the vertical distribution of white croppie (*Pomoxis annularis*) in two Oklahoma reservoirs. Proc. Ann. Conf. Southeast. Assoc. Game Fish Comm. 28:355-366.

GRAHAM, R. J. 1961. Biology of the Utah chub in Hebgen Lake, Montana. Trans. A. Fish. Soc. 90(3):269-276.

HARRIS, E. E. 1970. Reconnaissance bathymetry of Pyramid Lake, Washoe County, Nevada. Hydrologic Investigation Atlas HA-379, U.S. Geol. Surv.

HORAK, D. L. AND H. A. TANNER. 1964. The use of vertical gill nets in studying fish depth distribution, Horsetooth Reservoir, Colorado. Trans. Amer. Fisheries Soc. 93:137-145.

HUTCHINSON, G. E. 1957. Treatise on limnology, Vol. 1: Geography, physics, and chemistry. John Wiley & Sons, Inc., New York. 1015 pp.

______. 1967. A treatise on limnology, Vol. II: Introduction to lake biology and the limnoplankton. John Wiley & Sons, Inc., New York. 1115 pp.

JOHNSON, V. K. 1958. Fisheries management report—Pyramid Lake. Lakes Pyramid, Walker, and Tahoe Investigations. July 1, 1954 to June 30, 1958. Dingle-Johnson Project FAF-4-R. Nevada Fish and Game Department. 47 pp + appendices.

KIMSEY, J. B. 1954. The life history of the tui chub, *Siphateles bicolor* (Girard), from Eagle Lake, California. California Fish and Game. 40(4):395-410.

KOCH, D. L. 1972. Life history information on the cui-ui lakesucker (*Chasmistes cujus* Cope, 1883) endemic to Pyramid Lake, Washoe County, Nevada. Unpublished Ph.D. dissertation. Univ. of Nevada, Reno, 343 pp.

______. 1973. Reproductive characteristics of the cui-ui lakesucker (*Chamistes cujus* Cope) and its spawning behavior in Pyramid Lake, Nevada. Trans. Am. Fish. Soc. 102((1):145-149.

LANGDON, R. W. 1978. Food habits of the tui chub (*Gila bicolor*) in Pyramid Lake. Unpublished master's thesis. Humboldt State Univ. 43 pp.

LARIVERS, I. 1962. Fishes and fisheries of Nevada. Nevada State Fish and Game Comm. 782 pp.

LIDER, E. L. AND R. W. LANGDON. 1978. Plankton ecology. Chapter 9. *In*: W. F. Sigler and J. L. Kennedy (eds.). Pyramid Lake, Nevada ecological study—final report. W. F. Sigler & Associates, Inc. Reno, Nevada.

LINDENBERG, J. G. 1976. Seasonal depth distribution of landlocked alewives, *Alosa pseudoharengus* (Wilson), in a shallow, eutrophic lake. Trans. Am. Fish Soc. 105(3):395-399.

MARTIN, M. 1972. Morphology and variation of the Moduc sucker, *Catostomus microps* Rutter, with notes on feeding adaptations. Calif. Fish and Game 58(4):277-284.

MAY, B. E. 1973. Seasonal depth distributions of rainbow trout (*Salmo gairdneri*) in Lake Powell. Utah Acad. Sci., Arts, and Letters. 50(part 2):65-72.

MCCONNELL, W. J., W. J. CLARK, AND W. F. SIGLER. 1957. Bear Lake, its fish and fishing. Utah State Department of Fish and Game. 76 pp.

MILLER, R. G. 1951. The natural history of Lake Tahoe fishes. Unpublished Ph.D. dissertation. Stanford Univ. 160 pp.

NUNNALLEE, E., R. JOHNSON, AND O. MATHISEN. 1976. A hydrocoustic survey of the limnetic fish population of Pyramid Lake, Nevada. Final report to W. F. Sigler & Associates, Inc., Reno, Nevada. 13 pp + appendices.

OVERHOLTZ, W. J., A. W. FAST, R. A. TUBB, AND R. MILLER. 1977. Hypolimnion oxygenation and its effects on the depth distribution of rainbow trout (*Salmo gairdneri*) and gizzard shad (*Dorosoma cepedianum*). Trans. am. Fish Soc. 106(4):371–375.

RUSSELL, I. C. 1885. Geological history of Lake Lahontan. A Quarternary lake of Northwestern Nevada. U.S. Geol. Surv. Monogr. 11:xiv–288.

SNYDER, J. O. 1917. The fishes of the Lahontan system of Nevada and northeastern California. U.S. Bur. Fisheries Bull. 1915–16(35):31–86.

SUMNER, F. H. 1938. An investigation of the present status of the Pyramid Lake fishery, Nevada. Stanford University, California. June 30, 1938.

———. 1939. The decline of Pyramid Lake fishery. Trans. Am. Fish. Soc. 69:216–224.

UNITED STATES GEOLOGICAL SURVEY. 1977. Water resources data for Nevada, water year 1976. U.S. Dep. Inter., Carson City, Nevada. 344 pp.

VARLEY, J. D. AND J. C. LIVESAY. 1976. Utah ecology and life history of the Utah chub, *Gila atraria*, in Flaming Gorge Reservoir, Utah-Wyoming. Utah Div. of Wildlife Resources Pub. No. 76-16. 29 pp.

VIGG, S. 1978a. Seasonal bottom depth distribution of adult fish in Pyramid Lake, Nevada. Manuscript submitted to Calif. Fish and Game Journal, April 1978.

———. 1978b. Fish ecology. Chapter 8. *In*: W. F. Sigler and J. L. Kennedy (eds.). Pyramid Lake, Nevada ecological study—final report. W. F. Sigler & Associates, Inc. Reno, Nevada.

VIGG, S., AND D. L. KOCH. 1978. Thermal tolerance of Lahontan cutthroat trout, *Salmo clarki henshawi*. Manuscript submitted to Desert Research Institute. April 1978.

VON GELDERN, C. E., JR. 1964. Distribution of white catfish, *Ictalurus catus*, and rainbow trout, *Salmo gairdneri*, in Folsom Lake, California, as determined by gill netting from February through November 1961. Calif. Fish and Game Department. Inland Fisheries Admin. Report No. 64-15. Dingle-Johnsson Project California F-18-R.

AN ADDITION TO THE AMPHIBIAN FAUNA OF CALIFORNIA

David A. Mullen[1] and Robert C. Stebbins[2]

Abstract.— A population of salamanders of the genus *Ambystoma* has been found at Grass Lake, Siskiyou County, in Northern California. A five-year study has established that the salamanders are reproducing successfully and may represent a relictual population of native amphibians. The Grass Lake area has a sparse human population, which may help to explain how this secretive amphibian could have escaped notice. Attempts to determine the taxonomic position of the Grass Lake salamander, through comparisons of body measurements and coloration with those of other western ambystomatids, were inconclusive. These comparisons suggest, however, a close relationship with the geographically most proximate subspecies, *A.t. californiense* Gray and *A.t. melanostictum* Baird. Grass Lake is near the midpoint of a gap area of approximately 800 km that separates these subspecies. Regardless of the origin of the population, it must now be listed as an established addition to the amphibian fauna of California.

An adult ambystomid salamander was collected at Grass Lake, Siskiyou County, California, on 19 October 1969. The specimen was tentatively identified as a California tiger salamander, *Ambystoma tigrinum californiense* Gray, though its coloration and location more than 500 km north of the northernmost portion of the known range of this subspecies in the San Francisco Bay region did not strongly support this identification. Large numbers of these animals were observed three days earlier by Mr. John Q. Hines, a long-time resident and naturalist in the area. This was the first time that he had seen salamanders at the lake. The animals were crossing the road, moving away from the lake during the first heavy rain of the year.

The California tiger salamander occurs in central California, west of the crest of the Sierra Nevada from Sonoma County in the north to Santa Barbara County in the south (Stebbins 1966). It is found in foothill and valley grassland habitats from near sea level to approximately 1200 m elevation. The California form is distinguished from other western subspecies by its distinctive color pattern of oval, or bar-shaped, white, cream, or yellow spots on a black background color. It is isolated from the others by great distances, there being no representatives of the species known from the western part of the Great Basin south of the Columbia River area or in the Sonoran Desert.

The northern Great Basin, however, is occupied by the subspecies *A.t. melanosticum* Baird whose nearest populations along the Columbia River are found approximately 432 km north of Grass Lake. The coloration of this subspecies differs considerably from that of the Grass Lake animal.

The Grass Lake discovery initiated a five-year study of the area from October 1969 to October 1974, during which time many additional individuals were found. This paper reports the results of that study and attempts to illucidate the circumstances which could have permitted the undetected existence of such a large amphibian in the area. Comparisons of morphological data with those of other western subspecies of *A. trigrinum* are presented to suggest possible taxonomic relationships.

Habitat

Grass Lake is at an elevation of 1555 m in a shallow depression between Deer and Goosenest Mountains in the Cascade Range of northern California. U.S. Highway 97 crosses the lake approximately 34 km northeast of the town of Weed, California. This two-lane highway, built across the lake on a bed of earth and volcanic rock, was completed in May 1932 (Anonymous 1932a). It is a well-used roadway between central California and southeastern Oregon and carried 100 to 300 vehicles per day from its earliest days (Anonymous 1932b), a figure greatly exceeded today.

---

[1] Department of Biology, University of San Francisco, San Francisco, California 94117.

[2] Museum of Vertebrate Zoology, University of California, Berkeley, California 94720.

A rail line parallels the southern margin of the lake with a spur northward into the lake for a short distance. This spur was probably used to obtain water for steam engines, and a small area immediately around its terminus was dredged to a depth of 1 to 2 m, forming a basin which held water in all months of the year since its construction in September 1906. Except for a small cattle ranch and highway maintenance and U.S. Forest Service stations at the western end of the lake, there is no nearby human habitation.

The size of the lake varies greatly, depending upon seasonal precipitation and the flow of two small streams, Bear Wallow and Dairy Creeks, which empty into its northern side. When filled by spring runoff, the lake, situated in a closed basin, measures 4.25 km along its east-west axis, 1.75 km at its widest point. Its contour is very regular, except for the dredged area near the rail spur, which has a maximum depth of 1.5 m. The shoreline slopes gently into the lake around most of its perimeter.

The level of the lake can be controlled by regulating the flow of water into a volcanic vent, approximately 6 m in diameter, situated near the south-central shore. This drain has been encircled by an earthen dam to prevent natural drainage. The dam is breeched at two points by ditches which, when opened, can drain the lake completely to permit the grazing of cattle. The presence of this vent indicates that the lake may have formed in the remains of an old volcanic caldera. Attempts to trace the route of the effluent from this vent, using marker dyes, were unsuccessful.

Much of the lake bed supports a dense growth of tule bulrush, *Scirpus acutus*, which attains an average height of about 1 m. When the lake is drained, a mixture of native and introduced grasses and sedges grow under the Bulrush, providing the primary source of forage for cattle. There are small stands of common cat-tail, *Typha latifolia*, in the extreme western portion of the lake where somewhat deeper water occurs.

A narrow strip of heavily grazed land, grown to grasses and sedges separates the lake from the forested hill sides of mixed western juniper, *Juniperus occidentalis*, and yellow pine, *Pinus ponderosa*. The understory of the forest is primarily rabbit brush, *Chrysothaminus nauseosus*, and manzanita, *Arctostaphylas viscida*.

The lake is used for breeding and nesting by a wide variety of resident and migratory birds. Large wading birds, including the great blue heron and common egret, frequent the lake and probably prey heavily on reptiles and amphibians since there are no fish in the lake.

The Pacific tree frog, *Hyla regilla* Baird & Girard, long-toed salamander, *Ambystoma macrodactylum* Baird, and western toad, *Bufo boreas* Baird & Girard, are found in or near the lake, and the common garter snake, *Thamnophis sirtalis* L., is abundant. The burrows of the meadow vole, *Microtus montanus* (Peale), the western Mole, *Scapanus latimanus* (Bachman), and the pocket gopher, *Thomomys umbrinus leucodon* Merriam, are found around the lake and extend into it when it is drained. The salamanders probably use these mammal burrows as underground refuges.

Climatological data from the U.S. Department of Commerce Weather Station located at the nearby Mount Hebron ranger station indicates that the area has a mild climate for a mountain region. The weather at Grass Lake during this study was characterized by moderately warm summers, with a high mean monthly temperature of 17.3 C in July. The lake basin is subject to intermittent freezing and light snow from late October to early March, with a low mean monthly temperature in January of –4.0 C. Though the mean annual temperature of 6.5 C at Grass Lake did not differ greatly from the 9.0 C temperature recorded at Weed, only 34 km to the southwest, the difference in total precipitation at these two sites is striking. The mean annual precipitation at

Grass Lake during this five-year study was 35.9 cm compared to the 68.8 cm recorded at Weed during the same interval. This variation in precipitation over so short a distance illustrates the tremendous influence exerted over local weather patterns by the 4317 m Mount Shasta. Most of the precipitation falls in the form of rain during the winter and spring months of October through April. Summer thunderstorms account for a small portion of the total but can influence the level of Grass Lake significantly during critical summer periods.

METHODS

Because of the great distance from San Francisco to the study area and the difficulty experienced in finding specimens of the Grass Lake salamander, collecting trips were conducted mainly in October to coincide with the expected fall migration. Table 1 summarizes the conditions at Grass Lake and the collections made during this study. This information is presented to illustrate the difficulty encountered in our attempts to observe and collect specimens from a population we knew existed in the area. These difficulties offer some evidence, we believe, that this population may have existed, undetected in the area for a long time.

Preserved Material

Preserved material from the Grass Lake population was compared with that loaned by various western university museums. Loan materials were usually of random collections from widely scattered locations and often contained representatives of more than one subspecies of *A. triginum*. For the purpose of this study, unidentified specimens were designated members of a particular subspecies if the collection site was within the range of that subspecies according to the range maps of Stebbins (1966). Figure 1 (modified from Stebbins 1966) shows the areas from which the materials used in this study were collected and the subspecies to which they belonged.

Only data from fully transformed, adult specimens were compared. There was a general paucity of adult material available, with most loan collections composed of a few adults among large numbers of larvae. The difficulties encountered by the authors in obtaining adult specimens from the Grass Lake population suggest the reason for the

TABLE 1. Summary of observations and collections at Grass Lake, Siskiyou County, California.

	Date	Water level	Weather conditions	Specimens collected
1969	October 19	Low	Freezing with snow and ice present	1 (live)
	December 8	Low	Snowing, no ice present	1 (live)
	December 21	Low	Clear with freezing temperatures	4 (live)[a] 1 (dead)
1970	April 3–4	High	Clear, warm, and sunny	1 (live) 1 (dead)
	October 21	Low	Clear and dry	none
1971	October 22	High	Raining and warm	1 (live)
	October 23–25	High	Snow with melting snow present	1 (live) 1 (dead)
1972	October 13–15	High	Clear and dry, cold	none
	October 27–29	High	Clear and dry, cold	none
1973	October 13–14	Low	Clear and dry, warm	none
	October 20–22	Low	Overcast with freezing temperatures	none
1974	October 27	High	Raining with temperatures just above freezing	27 (live)

[a] Collected by Dr. John O. Sullivan, Department of Biology, Southern Oregon College, Ashlund, Oregon.

scarcity of adult material in other collections.

Data taken from preserved materials included: total body length, snout to tail tip; snout-vent length, from lower jaw to the anterior opening of the vent; head width at the posterior angle of the mouth; head length, from the tip of the snout to the fold of skin at the base of the skull; and the position of the eyes, distance between the in-

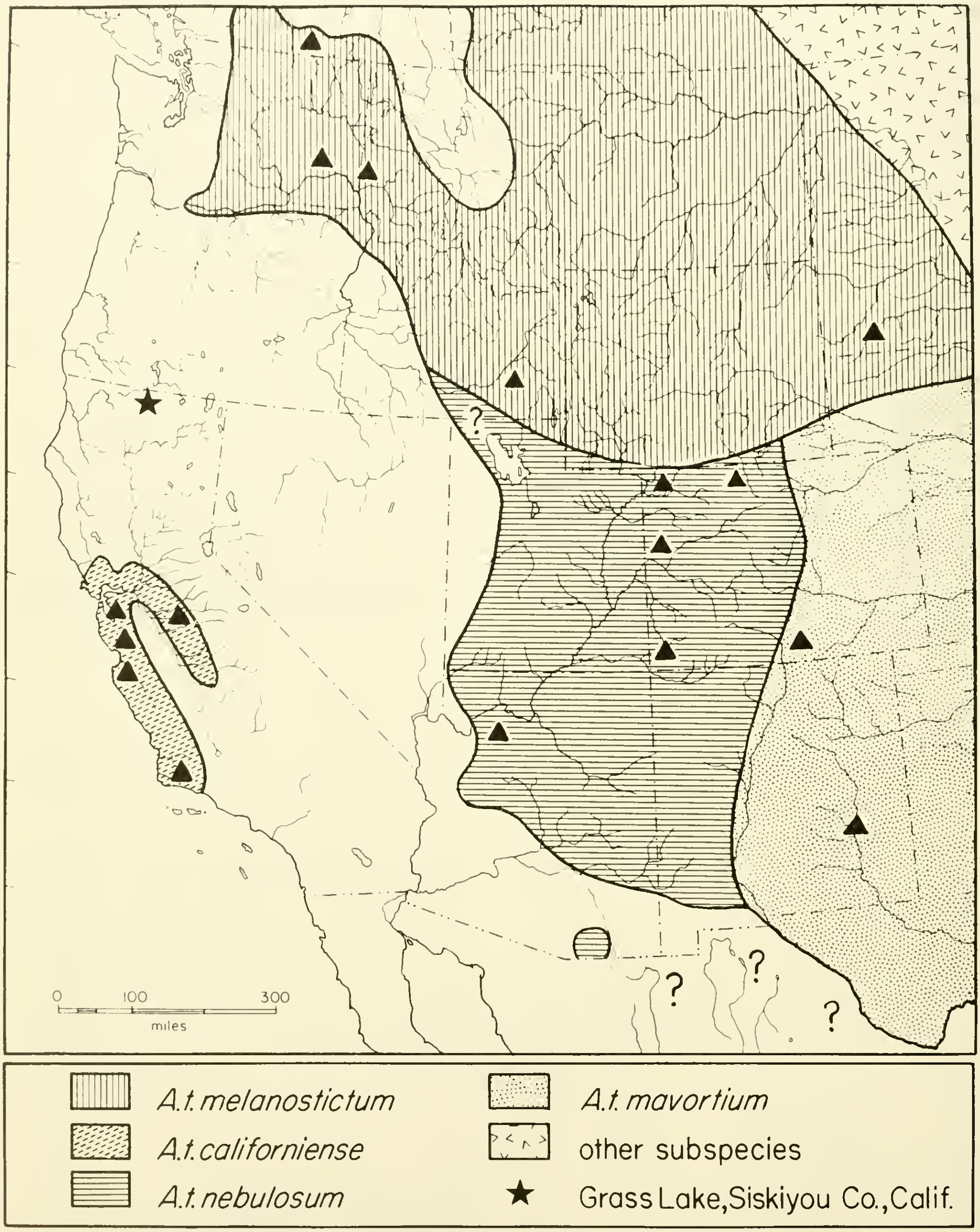

?
?
?
?
0
100
300
miles
A.t. melanostictum
A.t. californiense
A.t. nebulosum
A.t. mavortium
other subspecies
Grass Lake, Siskiyou Co., Calif.

Fig. 1. Map of the western United States showing the distribution of the subspecies of *Ambystoma tigrinum* (adapted and modified from Stebbins 1966.)

nermost eyelid margins. All measurements were taken with calipers to the nearest 0.1 mm. Colors and patterns of coloration were also noted for live and preserved specimens.

RESULTS

BODY MEASUREMENTS.—Measurements for western subspecies of *A. tigrinum* are presented in Table 2. Unfortunately, few adult specimens are available in collections and collecting efforts vary greatly. In southern populations of *nebulosum* Hallowell, for instance, almost all of the adult material available was collected at a single location and time. Allowing for these intrinsic sources of error, however, the Grass Lake salamander seems to more closely resemble the slightly smaller *californiense* and slightly larger *melanostictum* than it does the other geographically proximate subspecies *nebulosum* and *mavortium* Baird. If arranged in ascending order, the various measurements of the Grass Lake sample fall next to those of *melanostictum* in all comparisons and between this subspecies and *califoriense* in three of the five comparisons.

The ratios of certain body characteristics presented in Figure 2 are considered more useful as indicators of possible taxonomic relationships because they do not rely on sample size or the uniformity of collecting efforts. The subspecies are arranged according to their distance from Grass Lake.

The resemblance of the Grass Lake ambystomatid with other western subspecies of *A. tigrinum* is demonstrated. The possession of a slightly wider head with wider set eyes seems to be the only morphologic characteristic examined which might be diagnostic of the Grass Lake form.

COLORATION.—Living specimens of the Grass Lake ambystomatid usually have a black to dark, olive green dorsal, background color which gives way gradually on the lower flanks to a lighter grey-green color on the ventrum (Fig. 3). The background coloration is usually uniform from head to tail on both the dorsal and ventral surfaces and is overlaid by cream-colored, diffusely outlined, irregular spots which tend toward a mottled pattern on the flanks. This pattern extends onto the flanks, belly and gular areas in larger specimens and from the tip of the tail onto the head on the dorsum of most specimens.

Color comparisons of preserved specimens with those of other western ambystomatids, generally considered unreliable because of the variable effects of fixation, did not show any variations which could be considered unique. The Grass Lake salamander resembles *californiense* in the possession of cream rather than black spots, and *mela-*

TABLE 2. Comparison of body measurements taken from preserved specimens of the Grass Lake salamander with those of the western subspecies of *Ambystoma tigrinum.*

	Mean measurements in millimeters ± S.E. (Sample size)				
			Head		
Subspecies	Total body length	Snout-vent length	Width	Length	Eye width
melanostictum	161.6 ± 11.3 (13)	80.8 ± 5.4 (11)	17.9 ± 1.1 (13)	22.9 ± 1.6 (13)	8.51 ± 0.6 (13)
Grass Lake	150.0 ± 4.2 (30)	77.9 ± 2.0 (32)	19.3 ± 0.5 (33)	25.0 ± 0.6 (33)	8.69 ± 0.2 (33)
californiense	147.1 ± 8.0 (21)	77.9 ± 2.8 (21)	17.5 ± 0.6 (22)	25.3 ± 1.0 (22)	6.27 ± 0.2 (22)
nebulosum, southern	140.4 ± 2.8 (10)	72.4 ± 1.0 (10)	16.6 ± 0.2 (10)	22.9 ± 0.2 (10)	6.58 ± 0.1 (10)
nebulosum, northern	188.4 ± 6.7 (8)	86.0 ± 2.6 (9)	20.3 ± 0.6 (9)	27.4 ± 0.6 (9)	9.27 ± 0.3 (9)
mavortium	172.6 ± 13.4 (5)	86.6 ± 5.3 (5)	20.1 ± 1.5 (5)	26.3 ± 1.6 (5)	8.83 ± 0.6 (5)

nostictum in having mottling on a dark dorsal background. It is also similar to *californiense* in the extent to which patterns of spots extend over the upper body and onto the ventrum and gular regions. Although the individual variation in this characteristic is also great, the typical Grass Lake salamander tends to have a greater number of smaller and more diffuse spots on the dorsum and a more extensive ventral pattern than does *californiense.*

DISCUSSION

The population at Grass Lake is known to have maintained itself for nine years. It appears to be well established and should be listed as an addition to the amphibian fauna of California.

Local residents apparently knew nothing of the existence of salamanders at Grass Lake prior to 1969. One amateur naturalist who had lived at the Grass Lake Ranger

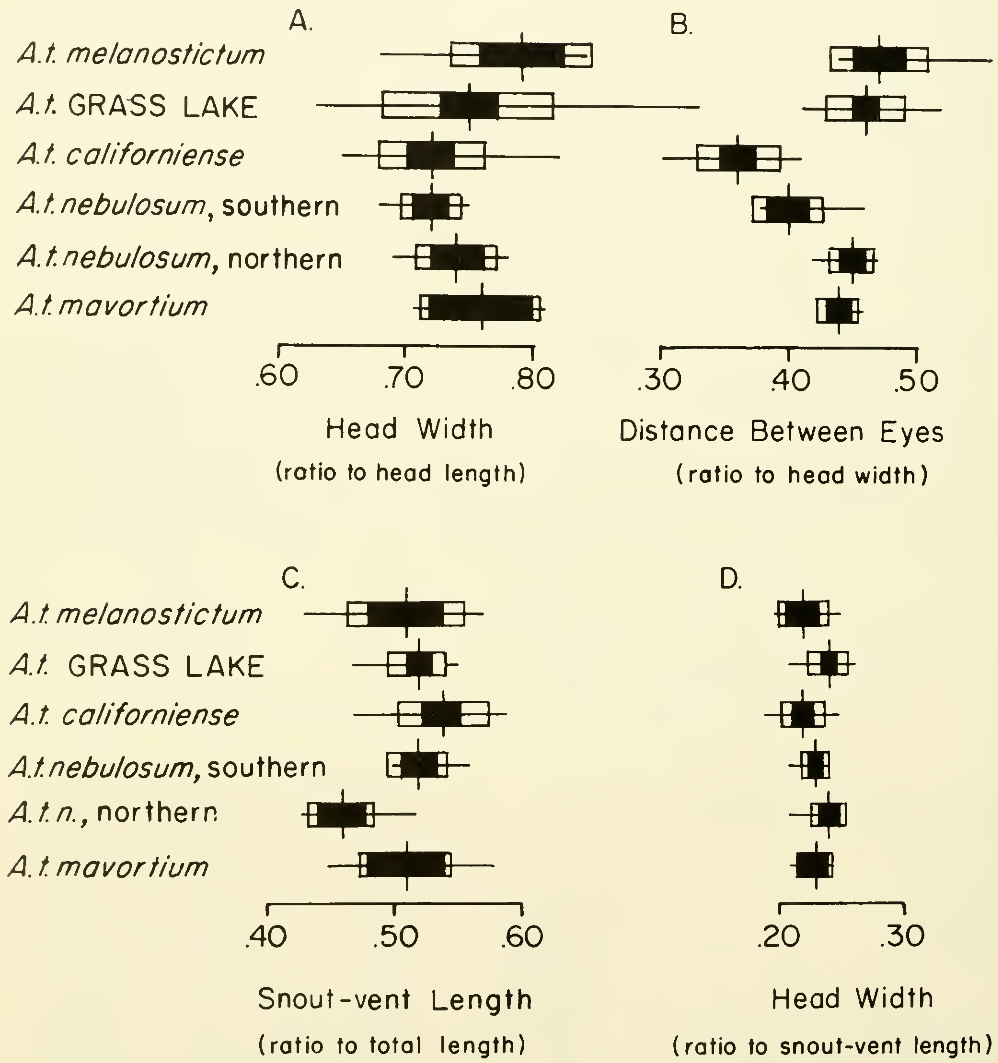


Fig. 2. Morphologic characteristics of the Grass Lake salamander compared with those of western subspecies of *Ambystoma tigrinum.* Horizontal line represents range; vertical line represents mean; open rectangle represents one standard deviation on either side of the mean; black rectangle represents twice the standard error of the mean on either side of the mean.

Station from 1953 to 1960 stated that she had never seen salamanders in the area, nor had she known of anyone who had. She was aware of the existence of a salamander nearer to Mount Shasta, probably *Ambystoma macrodactylum,* known to exist in that area. Other residents reported occasionally seeing "slimy lizards" in creeks which drained into the Klamath River away from Grass Lake. Occasionally caught on baited trout hooks, they were said to resemble mud puppies (*Necturus*) and were probably larval *Dicamptodon.*

A very large number of adult salamanders were first noticed migrating from Grass Lake in the fall of 1969. Reports of hundreds of salamanders crossing the highway from the lake indicate that the population had grown, unnoticed, to a substantial size. The migration is usually completed in a single night during the first heavy annual rainfall and would be observed mainly by motorists. Unless large numbers of salamanders were on the road, it is unlikely that disinterested motorists would report their presence. The animals blend with the pavement and could easily be overlooked during the hard rains that stimulate migration. Tiger salamanders in semi-arid western parts of the range are subterranian much of the year and are seldom encountered except during their brief breeding migrations. It is thus possible that a relatively large population could have existed in this isolated region for some time without being noticed. We obtained no larvae despite collecting attempts during both summer and winter months; however, our efforts were not intensive.

We have considered the possibility that the Grass Lake salamander was introduced. "Water dogs" had been used as fish bait in Dwinnel Reservoir, a large impoundment about 32 km southwest of Grass Lake. A re-

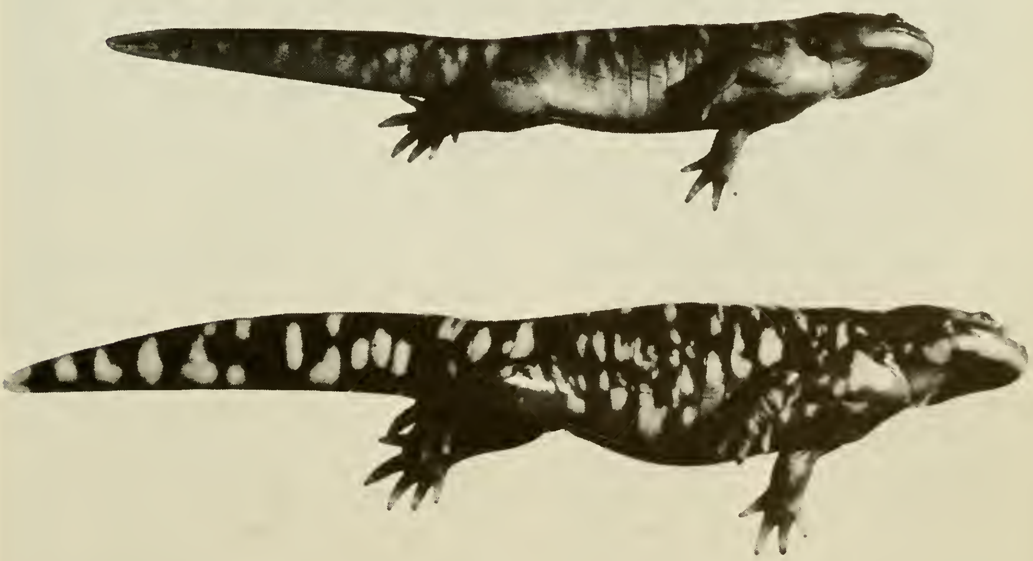


Fig. 3. Living, anesthetized *Ambystoma tigrinum* collected from Grass Lake, Siskiyou County, California. A. MVZ 99976, a 148mm female collected 8 December 1969; B. RCS 11766, a 186mm male collected 19 October 1969.

tailer in Weed stated that the best source of his bait had been a dealer from the state of Washington who had supplied good numbers of gilled larvae described as uniformly dark grey above and lighter grey below. This source was stopped by California authorities in 1965 or 1966. It is most probable that the subspecies involved in these transactions was *melanostictum*.

A second source of "water dogs," described as not having gills and with bright spots on the tail, was from a wholesaler who bought them in Texas or Louisiana. They were not as desirable a bait because they would not swim down into the lake as did the larvae from Washington. This circumstance, plus their much higher price, greatly limited the number imported. California authorities stopped their importation after 1969, though in that year alone the bait dealer sold more than 7,000 of them. It is most probable that the salamanders involved in these transactions were *A. t. mavortium* or the newt, *Notophthalmus viridescens*.

Another bait dealer in Redding, California, confirmed that they too had obtained good numbers of what they called "yellow water dogs" prior to 1969. These salamanders from a Texas supplier were described as about 10–12 cm in length and a uniform light yellow in color. Some had gills and some did not. It is again probable that these salamanders were *A. t. mavortium*.

After the Texas supply was stopped, small numbers of salamanders were obtained occasionally from wholesalers in Nevada. These animals were described as lacking gills and uniformly light grey in color. The subspecies involved in the Nevada transactions could have been *A. t. nebulosum*.

Bait purchased in the Redding area was usually used in nearby Lake Shasta. Very little bait was probably transported the 130 km northeast to Dwinnel Reservoir. Indeed, the great majority of fishermen would have traveled to this lake from the population-dense Redding area and farther south. Surviving baits, not released at the fishing site, would probably have been discarded by fishermen along the road leading from Dwinnel Reservoir to the southwest and away from Grass Lake. Oregon fishermen from the Klamath Falls area, most likely to use Highway 97 across Grass Lake, probably would not fish in California, where an out-of-state fishing license would be required. These factors tend to minimize the possibility of an accidental introduction of ambystomatids into Grass Lake. There remains, nonetheless, the possibility that the Grass Lake population of salamanders resulted from an accidental introduction of unused fish bait.

The Grass Lake population might have resulted from an increase in the numbers of an ambystomatid native to the area due to recent favorable environmental circumstances. If this is the case, the question remains: why were they not observed prior to 1969?

Access to the area was only possible by a system of unimproved logging roads prior to 1932. Efforts to study the biology of this remote area were probably few prior to this time, and it is possible that these rarely encountered animals could have been present, undetected, or unreported. With the paving of the road came travel across the lake on a daily basis by hundreds of vehicles. This increased traffic, however, would have passed quickly through the area and few travelers would have stopped, as there were no sidings or recreation facilities until the late 1960s. Further, the numbers of salamanders were probably very low and any limited use of the area for recreation would probably not have occurred during the rainy period when migration takes place.

Any discussion of the existence of a previously unknown ambystomatid native to the Grass Lake area, must account for their high numbers in 1969. The dredging and maintenance of the railroad water supply pond may have stabilized and even permitted a gradual increase in the numbers of a small population of salamanders by providing a stable breeding habitat. Later, agricultural practices at the lake, initiated in the 1960s, may have provided the necessary environment for a more rapid growth of the population. When the natural drainage was interrupted, the water level of the basin was significantly altered. This may have dramatically increased the breeding success of the population by providing a large, stable body of water necessary for increased reproduction while at the same time reducing the success of predators and permitting increased escapement of adults. Successful reproduction in this relatively arid, high altitude location would certainly depend heavily on the conditions at this small, isolated water source. The intervention of man may have proved highly beneficial and resulted in the resurgence of a relictual population.

Evidence from this study seems commensurate with the hypothesis that a relictual population of *Ambystoma tigrinum* has existed, undetected, in the Grass Lake area and that recent manipulation of the lake by man has permitted a resurgence of breeding success and growth of this remnant population. Additional study will be required to clarify its taxonomic position.

ACKNOWLEDGMENTS

We thank the following persons and institutions for the loan of specimens in their care: I. McT. Cowan, University of British Columbia; John M. Legler, University of Utah; T. Paul Maslin, University of Colorado, Boulder; and Richard L. Wallace, University of Idaho. Our appreciation also to Robert M. Winokur, University of Utah, for his generous donation of specimens from southwestern Utah and to John O. Sullivan, Southern Oregon College, for his provision of additional specimens of the grass Lake Ambystomatid and data concerning their ecology at that site. We also appreciate the opinions of Robert W. Reese, University of Colorado, Colorado Springs, and the time he expended to compare specimens of the new salamander with those in his collection. Finally, our sincerest appreciation to John Q. Hines for his many kindnesses during this study and for his assistance in the collection of field data and specimens from the Grass Lake area, and to Gene M. Christman for preparation of the illustrations.

LITERATURE CITED

Anonymous. 1932a. Final Report Covering Application of Heavy Fuel Oil and Asphaltic Road Oil as a Dust Palliative on Portions of the State Highway Between Weed and the Oregon State Line. State of Calif., Dept. Publ. Works, Div. Highways Rep., June 30, 1932.

———. 1932b. Preliminary Report Covering Construction of a Portion of Secondary State Highway between Dorris and the State Line in Siskiyou County. State of Calif., Dept. Publ. Works, Div. Highways Rep., Dec. 7, 1932.

Dunn, E. R. 1940. The Races of *Ambystoma tigrinum*. Copeia, 1940: 154–162.

Stebbins, R. C. 1966. A field guide to western reptiles and amphibians. Houghton-Mifflin Company, Boston, Massachusetts.

RAPTORS OF THE UINTA NATIONAL FOREST, UTAH

James A. Mosher[1], Clayton M. White[2],
Joseph R. Murphy[2] and M. Alan Jenkins[2]

Abstract.— The past and present use of the Uinta National Forest by birds of prey was determined from historical records and surveys conducted during 1973, 1974, and 1975. Data describing the history, present status, and physical characteristics of each nest site were collected, along with the type and intensivity of human activity within a half-mile radius of the nest. In addition, limited data on fall migration of raptors along the Wasatch Front and the food habits of Golden Eagles are presented. Management guidelines, based on the results of this study, are proposed.

The Uinta National Forest occupies an area in excess of 3600 km^2 in central Utah. It lies southeast of Salt Lake City (Fig. 1) and encompasses much of the Wasatch Mountain range and the northern portion of the San Pitch Mountains. The area is characterized by high, rugged mountains (to 3622 m) cut, especially on the western front, by deep canyons which are generally within the 1523 to 2745 m elevation range. These steep-walled canyons provide numerous potential nest sites for cliff-nesting birds. Riparian habitat found along the canyon floors and higher forested slopes and plateaus provide nesting habitat for woodland species. Habitat type changes with altitude, beginning with a zone of sagebrush at the valley floor and extending through scrub oak, aspen, and dense conifer before reaching the tree line. Each of these habitat types offer nesting potential for various species of raptors.

Agricultural and urban development are encroaching up the slopes of much of the western front of the Wasatch Range, and recreational development of the canyon areas is increasing. This activity and a generally increasing awareness of the susceptibility of some raptor species to human disturbances prompted the management personnel of the Uinta National Forest to initiate this study of its rare and endangered raptors. Field work relating to this study was conducted from January 1972, to June 1975. The goals of this research were to determine: (1) what species of raptors were found in the Forest; (2) when and where they used Forest lands; (3) Forest use by raptors, and particularly by Golden (*Aquila chrysaetos*) and Bald eagles (*Haliaeetus leucocephalus*) and Peregrine Falcons (*Falco peregrinus*); (4) guidelines for management of raptors.

Methods

An intensive literature search on Utah birds of prey was conducted, and the field notes of R. G. Bee (Brigham Young University Life Science museum) were searched and summarized. Public cooperation to increase sightings and nest records was solicited via radio and television publicity and distribution of posters.

Surveys by vehicles and on foot were conducted over most of the Forest from 1973 to 1975, paying particular attention to cliff areas. All recorded and reported nest sites were checked. Aerial surveys in a Cessna 172 were conducted over some extensive cliff areas and other areas of known Bald Eagle use during the winter.

Nest site data collected included elevation above sea level, height on cliff, height of cliff, directional orientation of nest site, occupancy history, distance to nearest human activity (i.e., roads, campgrounds, pastures, etc.), type and intensity of human activity within a half-mile radius of the nest site, breeding chronology, and prey remains. Estimates of home range sizes of Golden Eagles are based on multiple observations of individual birds, identified by characteristic plumage patterns, around active nest sites. Migration data were collected by direct observations from a point east of Provo, Utah, on the Wasatch Mountain front at about 1980 m above sea level.

---

[1] Appalachian Environmental Laboratory, CEES, University of Maryland, Frostburg State College, Frostburg, Maryland 21532.

[2] Department of Zoology, Brigham Young University, Provo, Utah 84602. Present address of Jenkins is: U.S. Fish and Wildlife Service, Denver Wildlife Research Center, Building 16, Denver Federal Center, Denver, Colorado 80225.

RESULTS AND DISCUSSION

Historical Summary

Table 1 is a compilation of raptor sightings on the Uinta National Forest up to the time of this study, largely from the unpublished field notes of R. G. Bee and K. Turley. Except as noted, breeding status is not given. More complete data are available for the Golden Eagle and Peregrine Falcon. Table 2 summarizes the history of the Golden Eagle nest sites. Old nests located during this study were listed as sites with no recorded activity. Identification of Golden Eagle nests was based on size and location.

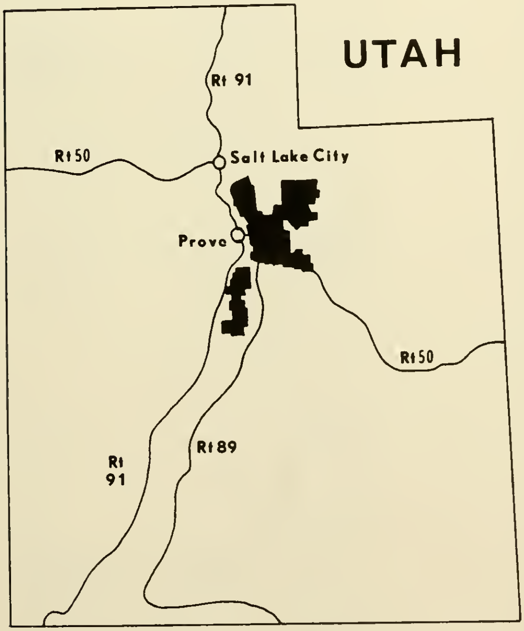


Fig. 1. Location of the Uinta National Forest (1972) within Utah.

There is a long history of breeding activity by Golden Eagles in the Uinta National Forest. It is the most conspicuous breeding raptor. Allowing for alternate nest sites, some 21 territories are now known. Based on Bee's field note records of nest sites, the number of eagles appears to have changed little since the 1930s. The breeding season for this species extends from January to late June (Smith and Murphy 1973, and this study).

The Peregrine Falcon has occupied three known eyries in the forest. The last known nesting activity was in 1968. According to Porter and White (1973), "... the known active eyries of this species in Utah are now only about 10 percent of those known to have been present earlier in the century." The Peregrine was first recorded in Utah in 1871 (Allen 1872) and the first active eyrie reported in 1899 (Johnson 1899). Fossil evidence establishes both the Peregrine and the Prairie falcons (*Falco mexicanus*) in Utah back perhaps as far as 40,000 years (Porter and White 1973).

The known range of the Peregrine in Utah includes only a small part of the Uinta National Forest lands; however, three prior eyrie locations are known within the Forest boundary (Porter and White 1973). The history of these eyries is reproduced from Porter and White (1973) in Table 3. We have a recent report of repeated sightings of a Peregrine in the Spring Lake area from April to June or July 1972 (Turly, pers. comm.). An interesting review of the history and status of the Peregrine Falcon with references to relations with the Prairie Falcon in Utah is to be found in Porter and White (1973). Very little historical information about the Prairie Falcon in central Utah is available. It was, however, reported to be common in the rocky canyons of the Wasatch Mountains prior to the turn of the century (Ridgway 1874). We have records of its nestings in six locations on Forest land from 1930 to 1940, as well as sightings in four other Forest locations up to 1955. These birds may still nest on the Forest, although no individuals were seen during this study.

Recent Activity

The results of the 1973 survey, which was the most extensive and systematic survey, are summarized in Table 4. These results need careful interpretation because birds are not necessarily sighted in proportion to their actual numbers. Eagles and Turkey Vultures (*Cathartes aura*) are very conspicuous because of their size and soaring habits. Kestrels (*Falco sparverius*) are also very conspicuous in spite of their small size because they hunt from perches (especially power lines) near roadways. Buteos are generally conspicuous, but less so than eagles

TABLE 1. History of raptor sightings on the Uinta National Forest prior to 1973.

Species	Date (month/year)	Location
Bald Eagle	10/69	Mt. Timpanogos
Golden Eagle (see also Table 2)	3/69	Y Mountain
	4/69	Mt. Nebo
	W-'72/'73	South fork, Provo
Peregrine Falcon	4-6/72	Spring Lake
Prairie Falcon	4/29	?
	*3/30	Dry Canyon, Mona
	*5/30	Provo Canyon
	*3/31	Alpine (several years), Fort
	*4/36	Grove Canyon
	*4/38	Days Canyon, Hobble Creek
	*4/40	Alpine, Box Elder
Sharp-shinned Hawk	5/71	Spring Lake
	*5-8/72	Spanish Fork, Canyon
Cooper's Hawk	10/71	Spring Lake
Goshawk	8/70	Rock Canyon, Provo
	6/71	Left fork, White River
	2/72	Spring Lake
	12/72	Wallsburg, south
Harris Hawk	8/72	Current Creek guard station
Red-tailed Hawk	3/69	Fairview
	1/70	Current Creek
	3/71	Spring Lake
	2/72	Spring Lake
Rough-legged Hawk	1/72	Spring Lake
Swainson's Hawk	8/69	Nebo Loop Road
Turkey Vulture	8/72	Nebo Loop Road
Boreal Owl	3/69	Provo
Great Horned Owl	2/68	Y Mountain
	1/71	Spring Lake
	1/72	Spring Lake
Long-eared Owl	*7/72	Squaw Peak Trail
Pygmy Owl	12/71	Diamond Fork
Saw-whet Owl	1972	Dry Canyon, Linden
Screech Owl	6/72	Spring Lake
Short-eared Owl	1/71	Spring Lake
Spotted Owl	7/71	Rock Canyon

*Indicates sighting was at active nest.

or vultures. Falcons and accipiters are quite inconspicuous. Owls, by their nocturnal or crepuscular habits, are the least conspicuous of all in diurnal surveys.

Subjective estimates of population density were made for several resident species by estimating availability of suitable habitat, relative degrees of conspicuousness, and numbers seen on the Uinta National Forest. These were as follows: Golden Eagles, 84 (1/39 km^2); Kestrels, 128 (1/26 km^2); Red-tailed Hawks (*Buteo jamaicensis*), 60 (1/54 km^2); Harriers (*Circus cyaneus*), 16 (1/202 km^2); and Turkey Vultures, 52 (1/62 km^2). The total raptor density for these species was 1 per 9.6 square kilometers. There was insufficient information to permit an estimate of population sizes for the other species. Some are, of course, wintering birds or migrant visitors.

Fall Migration

The use of north-south-oriented mountain chains by migrating raptors is a well known phenomenon, and the observation of fall mi-

Table 2. Nest site history of Golden Eagles on the Uinta National Forest.

Nest Site		1973	1972	1971	1970	1969	1968	1967	1966	Records prior to 1966**
Alpine	–Dry Canyon		A							'32, '34, '40, '50, '51
	–Fort Canyon	A								
American Fork	–Canyon Head									'33, '51
	–Mt. Timpanogos–N									'34
	–Pittsburgh Lake									'42
Heber	–East of 40 and 189*	A								
Levan	–Chicken Creek									
	–Deep Creek–N									
	–Deep Creek–S	A								
	–Pigeon Creek Road									
	–Pigeon Creek Trail									
Nephi	–Footes Canyon									
	–Red Cliffs									
	–Hop Creek*									
	–Salt Creek–S									'37
Pleasant Grove	–Grove Canyon									'37, '38, '39, '46
Provo	–Cascade		A							
	–Rock Canyon									'37, '40, '41, '44
	–Y Mountain									'33
	–Wallsburg–W									'39
	–Wildwood									'38, '39, '40, '41 '44, '46
Spanish Fork	–Lower Diamond Fork	A			A	A	A	A		
	–Upper Diamond Fork		Ⓐ							'31, '45, '46, '55
Springville	–Little Rock Canyon									
	–Balsam Campsite									
	–Days Canyon									'38
	–Kirkman Divide		A							
	–Power House							Ⓐ		'55
	–Hobble/Diamond									'45
	–Sulphur Campite									'37
Strawberry	–Current Creek*	A								
	–Current Creek and 6*									
	–Current Creek and 10									
	–Current Creek and 12									
	–Current Creek–W*									'41
Thistle	–Big Jane Canyon	A	A							
	–South*									
Wales	–UNF boundary	A								

A = Active nests
Ⓐ = Unsuccessful nests (i.e., no young fledged)
* = Not inside UNF boundary
** = Records from the field notes of R. G. Bee

grations from look-out points provides much useful population data (e.g., Hawk Mountain Sanctuary, Heintzelman 1975). The Wasatch Front, which forms the eastern boundary of the Great Basin, would appear to provide a similar corridor in the intermountain west. Data collected on the Uinta National Forest near Provo, Utah, from 1972 to 1974 suggest that considerable raptor movement occurs along this Front (Table 5) and more continuous observation might prove valuable. The greatest amount of movement apparently occurred about mid-September, when 35 and 60.5 birds per hour of observation were recorded.

TABLE 3.—History of Peregrine Falcon eyries on the Uinta National Forest.[1]

Site no.	First located and subsequent history	Last known to be active
17	1930s, 1940s, 1950s, 1967	1968
18	1930s, 1939–46	1969
19	1930–32	1932

[1] Taken from Table 1 of Porter and White (1973)

TABLE 4. Summary of 1973 raptor sightings on the Uinta National Forest.

Species	Number of individuals	Number of sightings	Season present	Number of nest sites	Number active	Number fledged
Bald Eagle	27	8	FWS			
Golden Eagle	42	35	SFWS	27	4	4
Osprey	2	3	t[1]			
Sharp-shinned Hawk	2	2	SFW			
Cooper's Hawk	11	8	SFWS	5	4	
Goshawk	2	2	SFWS			
Ferruginous Hawk	1	1	SFS			
Red-tailed Hawk	15	13	SFWS			
Rough-legged Hawk	2	3	FWS			
Swainson's Hawk	4	2	SFS			
Harrier	8	6	SFWS			
Kestrel	32	20	SFWS	4	4	
Merlin	1	1	t			
Peregrine Falcon	1	1	SFWS			
Prairie Falcon	2	2	SFWS			
Turkey Vulture	39	16	SFS			
Great Horned Owl	3	3	SFWS			
Snowy Owl	1	1	WS			
Total of 18 species	195	127		36	12	4

[1] t means transient

TABLE 5. Observations of fall movements of raptors along the Wasatch Front at Provo, Utah[1]

	Date (Hours of observation)															
	August		September								October					Totals
	18 (2.25)	25 (2)	2 (1)	4 (0.5)	9 (5.5)	15 (2)	20 (2)	22 (2)	27 (2)	29 (1)	4 (2)	6 (1)	7 (2)	13 (1)	19 (2)	
Sharp-shinned	0	2	1	0	16	32	1	0	13	2	7	3	2	0	0	79
Cooper's	0	0	0	0	3	1	1	0	4	2	1	1	0	0	1	14
Red-tailed	0	2	0	1	8	1	2	0	10	0	0	0	1	0	5	30
Ferruginous	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Golden Eagle	1	1	0	1	2	1	0	7	1	5	0	0	0	0	1	20
Harrier	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
American Kestrel	3	2	0	0	8	30	112	0	11	1	5	0	1	0	0	73
Unidentified	0	3	0	3	4	5	0	7	0	0	0	1	0	0	0	23
Total	4	10	1	5	41	70	116	14	44	10	13	5	4	0	7	341
Totals/hour of observation	1.8	5	1	10	7.5	35	60.5	7	21	11	6.5	5	2	–	3.5	

[1] Combined for 1972, 1973 and 1974

Wintering Bald Eagles

Field observations from January 1973 through May 1974 point out two aspects of the wintering Bald Eagle population. First, eagles are dispersed over the Forest during the arrival and departure periods. Second, a midwinter concentration occurs along the lower 14 km of one stream drainage in the southern sector.

During February 1974, aerial and ground surveys were conducted in an effort to locate a communal roost site for the dozen or more eagles observed in the area. The aerial survey was conducted at sunrise and the ground survey from late afternoon to sundown. Individual eagles were observed, but no communal roost was located. Unlike the desert population of Bald Eagles described by Platt (1976), where roosting is limited to relatively few groves of suitable trees, the Forest population has an abundance of roosting sites.

Golden Eagle Nesting and Human Disturbance

The Golden Eagle is a year-round resident and cliff nester on the Uinta National Forest. In 1973 and 1974, 18 pairs laid a total of at least 11 eggs and successfully fledged 10 young between 3 June and 29 June (Table 6). Nest sites were situated on cliff ledges exclusively and averaged 1891 m in elevation (1495 to 2562 m). There was a significant tendency ($\alpha = 0.01$, $n = 37$) for nests to be situated in a northward direction (Mosher and White 1976).

Prey remains collected at three nest sites are summarized in Table 7. These data contrast sharply with comparable data from desert nesting eagles, in that the mountain birds have a broader prey base and appear to rely less heavily on the Black-tailed jackrabbit (*Lepus californicus*) (Smith 1971). Prey which inhabit the higher elevations, such as Blue Grouse (*Dendragapus obscurus*), Mule Deer fawns (*Odocoileus hemionus*), and Snowshoe Hare (*Lepus americanus*), are of particular interest. These data may reflect a low rabbit density which prevailed during this study.

An estimate of minimum territory size was provided by multiple observations of two nesting pairs of eagles. The observations were plotted on 7½ minute USGS topographic maps and the perimeter points connected. The area contained within the polygon thus formed was estimated using a 1/10 in^2 grid. The territory sizes were 8.8 and 17.9 km^2, averaging 13.3 km^2.

The effect of human activity on nesting raptors is an area of debate. Although few "hard" data exist, this is an important aspect of raptor management. In this study, we recorded several types of human activities and their estimated intensity within 0.8 km of active and inactive Golden Eagle nests (Table 8). The most common activity

Table 6. Golden Eagle nesting, 1974.

Nest site	Pair in attendance		Eggs laid		Young fledged		Fledging date	
	1973	1974	1973	1974	1973	1974	1973	1974
Heber	yes	yes	yes	no	1	—	6/3-10	—
Alpine—Dry Canyon	yes	yes	—	yes	—	2	—	6/27
Pleasant Grove—Chris Flat	—	yes	—	?		?	—	—
Provo—Cascade	yes	yes	—	?		no	—	—
Springville—Hobble Creek (Sulphur)	yes	yes	—	yes	—	1	—	by 6/29
Diamond Fork—lower	yes	—	2	—	1	—	6/19-20	—
Diamond Fork—7 mi. cliff	—	yes	—	yes	—	1	—	by 6/29
Thistle—Big Jane Canyon	yes	yes	yes	no	1	—	by 6/28	—
Spring Lake	—	yes		yes			(nest destroyed)	
Payson Canyon	no	yes	—	yes	—	1	—	?
Levan—Chicken Creek	no	yes	—	?	—	?	—	—
Levan—Deep Creek	yes	no	yes	—	1	—	6/10-16	—
Wales—UNF boundary	yes	no	yes	—	1	—	by 6/28	—
Totals	8	10	6	5	5	5	6/3-28	6/27-29

TABLE 7. Golden Eagle food habits on the Uinta National Forest.

Prey species	Nest site and year				
	Hobble Creek	Diamond Fork		Alpine	
	1974	1969–79[*]	1973	1974	Total
Mule Deer	1			2	3
Black-tailed Jackrabbit		12	2		14
Cottontail Rabbit		6			6
Snowshoe Hare	3				3
Uinta Ground Squirrel	1	2	1	1	5
Rock Squirrel		5			5
Muskrat		2			2
Domestic Sheep			1		1
American Coot		1			1
Blue Grouse	1	1			2
Black-billed Magpie			1		1
Common Flicker		2			2
Steller's Jay		1			1
Unidentified Blackbirds		2			2
Nest site totals	6	34	5	3	48

[*] From W. B. Arnell, 1971

TABLE 8. Human activity at active and inactive Golden Eagle nest sites.

Active sites	Observed activity (intensity)[1]
1—Alpine—Dry Canyon	Hiking, vehicle traffic (1)
2—Alpine—Fort Canyon	None
6—Heber—40 and 189	Vehicle traffic, Shooting (2)
8—Levan—Deep Creek	Vehicle traffic (1)
13—Pleasant Grove—Chris Flat	Vehicle traffic, grazing (1)
14—Provo—Cascade	Vehicle traffic (1)
18—Spanish Fork—Upper Diamond	Vehicle traffic, hiking, climbing, shooting (3)
19—Spanish Fork—Lower Diamond	Climbing, grazing, shooting (1)
23—Springville—Sulphur Creek[1]	Vehicle traffic, camping, hiking, climbing, shooting (3)
24—Strawberry—Current Creek 1	Vehicle traffic (2)
27—Thistle—Big Jane	Vehicle traffic, grazing, hiking, shooting (2)
28—Wales—UNF boundary	Vehicle traffic (1)
30—Spring Lake	Climbing (3)
Inactive sites	
9—Levan—Pigeon Creek	None
10—Nephi—Red Cliffs	Vehicle traffic (1)
11—Nephi—Hop Creek	Grazing (1)
12—Pleasant Grove—Grove Canyon	Riding, hiking, shooting (3)
15—Provo—Rock Canyon	Vehicle traffic, riding, hiking, shooting (3)
20—Springville—Power House	None
21—Springville—Kirkman Divide	None

[1] Intensity classes are (1) little or none, (2) moderate, (3) severe. Classifications were assigned on basis of frequency, proximity, and number of types of disturbance present within a half mile of the nest site.

was vehicular traffic. The relationships between intensity and type of activity near active and inactive nests are shown in Figure 2. Sample sizes are small, but the results suggest that there may be a great deal of individual variability in tolerance by eagles to one or more types of activity. Of 12 active nests in 1973 and 1974, five were visited on three or more occasions to collect data. No difference in fledging success between nests visited and not visited was found (Table 9). The failure of one nest was attributed directly to removal of the egg by rock climbers.

The following management guidelines were recommended to the Uinta National Forest as a result of the study:

1. All known Peregrine Falcon eyries should be preserved from further man-induced alteration until decisions are made about reintroduction, via captive breeding, of this species to central Utah.

TABLE 9. Fledging success of disturbed and undisturbed Golden Eagle nests.

Nest site	Year active	Disturbed[1]	Fledging success
1—Alpine—Dry Canyon	1974	Yes	2
2—Alpine—Fort Canyon	1973	No	1
6—Heber—40 and 189	1973	No	1
8—Levan—Deep Creek	1973	No	1
14—Provo—Cascade	1973	No	1
18—Diamond Fork—Upper	1974	No	1
19—Diamond Fork—Lower	1973	Yes	1
Springville—23—Sulphur Camp	1974	Yes	1
23—Sulphur Camp	1975	No	(1)
28—Wales	1973	No	1
29—Payson Canyon	1974	Yes	1
30—Spring Lake	1974	Yes	0

Disturbed sites—5, Mean fledging success—1
Undisturbed sites—7, Mean fledging success—1

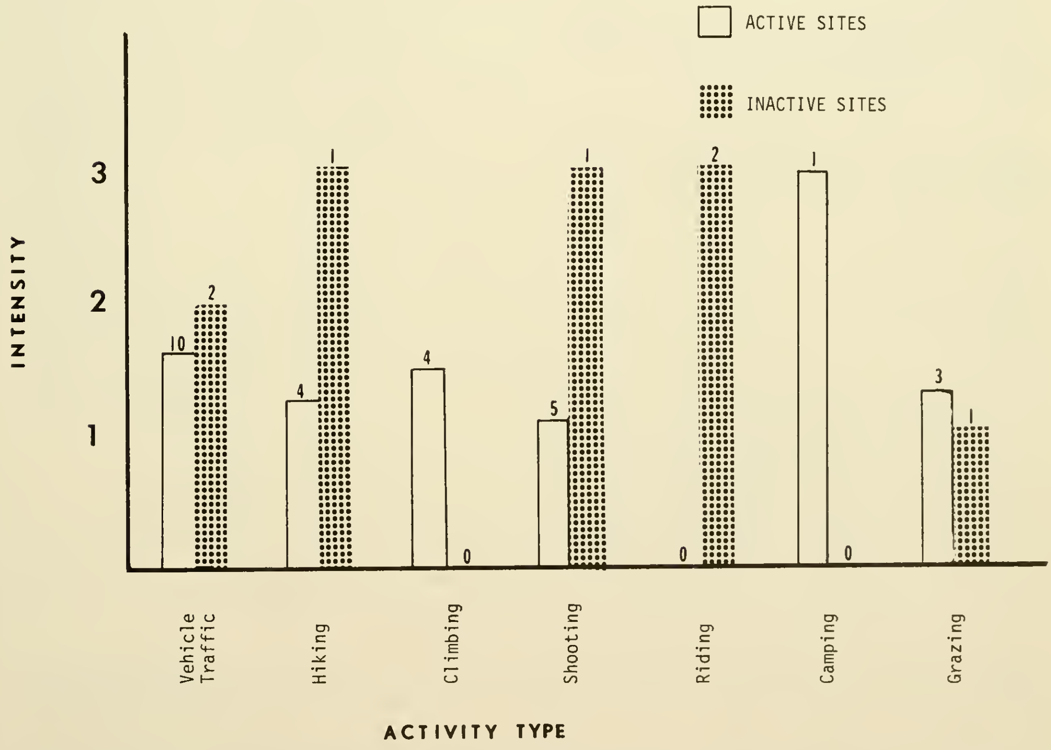


Fig. 2. Comparison of intensity of disturbance by type of activity at active and inactive Golden Eagle nest sites. (Numbers above bars refer to the number of nest sites in the sample.)

2. Human activity compatible with raptor nesting be permitted, provided the following criteria are met:
    (a) no major alteration affecting the actual nest site or prey base occurs.
    (b) disturbance is minimized prior to hatching.
    (c) the nest cliff itself is protected from climbing.
3. Raptor surveys should be conducted annually to monitor population status.
    (a) Golden Eagle nest sites should be checked during late May or early June to determine breeding activity and productivity.
    (b) Road count of Bald Eagles should be conducted during January or February.

ACKNOWLEDGMENTS

This study was funded by the U.S. Forest Service, Uinta National Forest, under Contract 50-905.

We are grateful for the support provided by the Uinta National Forest personnel, especially R. Wiesert, F. Savage, and K. Turley.

Critical reviews of earlier drafts of this paper by Dr. C. P. Stone and Dr. G. A. Feldhamer were particularly helpful.

This is Contribution 848, Appalachian Environmental Laboratory, Center for Environmental and Estuarine Studies, University of Maryland.

LITERATURE CITED

ALLEN, J. A. 1872. Notes on an ornithological reconnaissance of portions of Kansas, Colorado, Wyoming, and Utah. Bull. Mus. Comp. Zool. 3(6):113–183.

HEINTZELMAN, D. S. 1975. Autumn hawk flights. Rutgers Univ. Press, New Brunswick, New Jersey. 397 pp.

JOHNSON, H. C. 1899. A successful day with the Duck Hawks. Condor 1(3):45–46.

MOSHER, J. A. AND C. M. WHITE. 1976. Directional exposure of Golden Eagle nests. Canad. Field Natural. 90(3):356–359.

PLATT, J. B. 1976. Bald Eagles wintering in a Utah desert. Amer. Birds 30(4):783–788.

PORTER, R. D., AND C. M. WHITE. 1973. The Peregrine Falcon in Utah, emphasizing ecology and competition with the Prairie Falcon. Brigham Young Univ. Sci. Bull., Biol. Ser. 18(1):1–74.

RIDGWAY, R. 1874. Notes on the bird fauna of the Salt Lake Valley and adjacent portions of the Wasatch Mountains. Bull. Essex Inst. 5:168–173.

SMITH, D. G. 1971. Population dynamics, habitat selection and partitioning of breeding raptors in the eastern Great Basin of Utah. Ph.D. dissertation. Brigham Young University. 260 pp.

SMITH, D. G. AND J. R. MURPHY. 1973. Breeding ecology of raptors in the eastern Great Basin of Utah. Brigham Young Univ. Sci. Bull., Biol. Ser. 18(3):1–76.

TWO NEW SPECIES OF FLEAS OF THE GENUS *MERINGIS* (SIPHONAPTERA: HYSTRICHOPSYLLIDAE)

Richard B. Eads[1]

Abstract.— Two new species of *Meringis* are described. *Meringis disparalis*, n. sp., has been most commonly taken from *Dipodomys merriami* but has also been taken from *D. ordii* and *Onychomys leucogaster*. Collection localities include the counties of Dona Ana, Eddy, and Luna in southern New Mexico. *Meringis facilis*, n. sp., has been taken from *D. ordii*, several other rodents, and *Sylvilagus audubonii*. Collection localities include Crowley County, Colorado, and Bernalillo, Chaves, and Valencia counties in New Mexico. A key to the species of ♂ *Meringis* is given.

Numerous fleas in the collection of the New Mexico Health and Social Services Department and this facility labeled *Meringis dipodomys* from New Mexico and Colorado were studied. It is believed that two previously undescribed species are present. True *M. dipodomys* have not been seen east of Arizona. Holotypes and allotypes of the new species are in the National Museum of Natural History, Washington, D.C. Paratypes are in the collections of this laboratory and the New Mexico Health and Social Services Department, Santa Fe.

In addition to these 2 *Meringis* species, the other 15 species in this genus which I consider valid are: *M. agilis* Eads 1960, *M. altipectin* Traub and Hoff 1951, *M. arachis* Jordan 1929, *M. bilsingi* Eads and Menzies 1949, *M. deserti* Augustson 1953, *M. dipodomys* Kohls 1938, *M. nidi* Williams and Hoff 1951, *M. rectus* Moreland 1953, *M. vitabilis* Eads 1960, *M. californicus* Augustson 1953, *M. cummingi* Fox 1926, *M. hubbardi* Kohls 1938, *M. jamesoni* Hubbard 1943, *M. parkeri* Jordon 1937, and *M. shannoni* Jordan 1929.

Meringis disparalis, n. sp.

Figs. 1–5

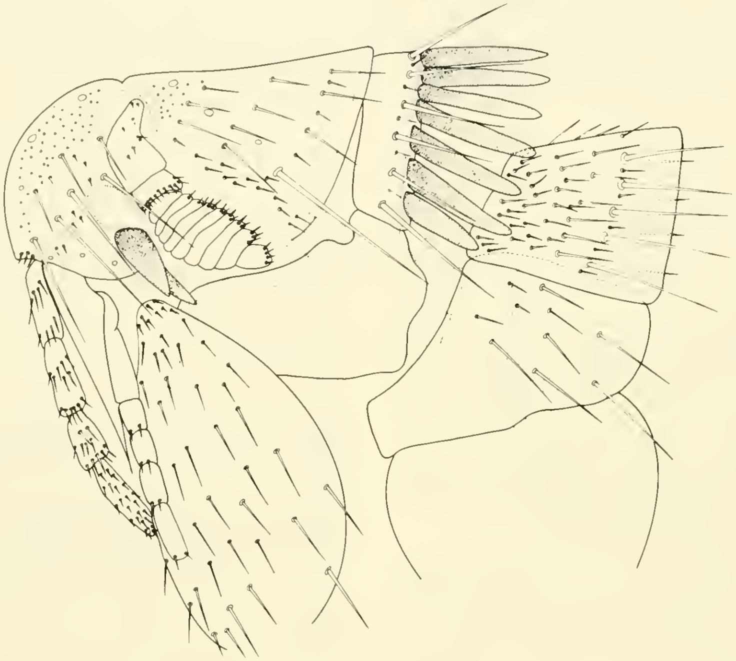
Diagnosis.— In the male an apical sinus divides the immovable process of the clasper into two equal lobes in *disparalis*; in *dipodomys* these lobes are markedly unequal. The *arachis*-group of *Meringis* is unique in that the posterior margin of the caudal process of sternum 9 is truncate, forming almost 90 degree angles at the juncture with the dorsal and ventral margins. The caudal process is short in *disparalis*, not reaching subapical spiniform bristles of distal arm of sternum 9; in *dipodomys*, the caudal process usually extends beyond the subapical spinform bristles of sternum 9. *Meringis disparalis* females have a sinus on the caudal margin of sternum 7 that is shallow relative to that of *dipodomys*, but a definite dorsal lobe is usually present.

Male.— *Head*: Frontoclypeal margin evenly rounded. Micropunctations or pores scattered from first row of bristles to margin of head. Preantennal region with three large dermal pores along cephalic margin and three smaller pores along ventral margin. First preantennal row of three thin bristles, caudal or ocular row of four larger bristles; a few microsetae interspersed between bristles in each row; ventrad of reduced, lightly pigmented eye an irregular row of about five microsetae. Genal process bluntly acuminate, apex barely visible beyond genal comb which arises ventrad of eye; outer spine superimposed on basal

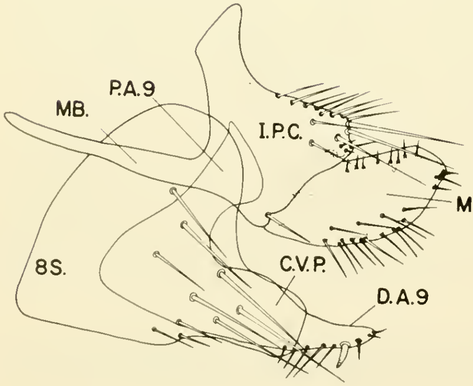
---

[1] Vector-Borne Diseases Division, Center for Disease Control, Public Health Service, U.S. Department of Health, Education, and Welfare, P.O. Box 2087, Fort Collins, Colorado 80522.

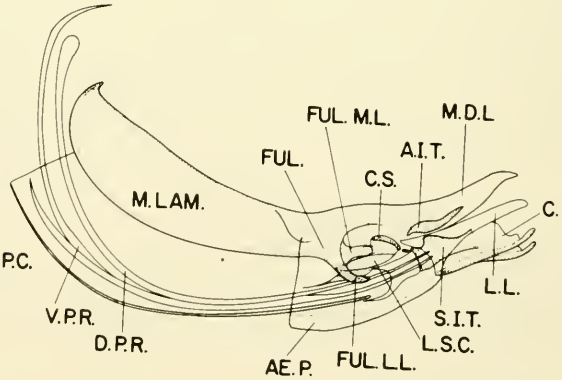
three-fourths of narrower but longer inner spine; inner spine more acuminate at apex than outer spine. Three short, stout setae at oral angle of head at base of 4-segmented maxillary palp. Acuminate maxillary lobe extending almost to apex of segment 3 of 5-segmented labial palp. Labial palp longer than maxillary palp, reaching about three-fourths length of fore coxae. Scape of antenna with three tiny bristles at base and four somewhat larger median ones; second antennal segment with apical fringe of short bristles not extending beyond segment 1 of club. A row of fine hairs along the dorsal



1



2



3

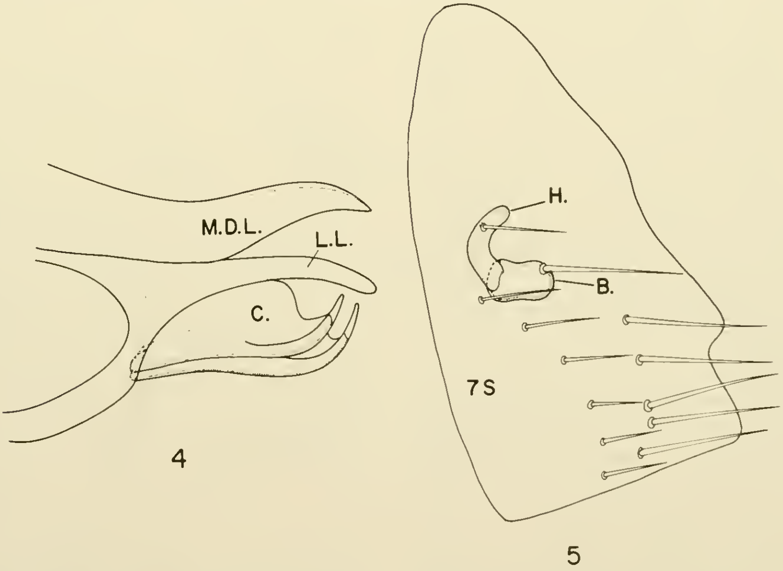
Figs. 1–3. *Meringis disparalis*: (1) ♂ head, pro- and mesothorax; (2) ♂ modified abdominal segments; (3) aedeagus.

margin of antennal fossa, caudal two longest. Three rows of postantennal bristles arranged about 3:5:5, ventrad bristle longest in each row.

Thorax: Pronotal comb of seven spines per side, preceded by a row of seven large bristles with fine intercalary bristles. Anterior and posterior margins of pronotum almost straight, about same width throughout. Mesonotal flange with four pseudosetae per side. Mesepisternum with one median bristle along pleural rod preceded by a smaller one; mesepimeron with four cephalic bristles in an irregular row and a caudal row of two larger ones. Metanotum with a short row of three or four bristles, followed by a row of seven or eight medium-sized bristles and a row of about six longer bristles alternating with small ones. Lateral metanotal area well defined, with an oblique row of four bristles (dorsal bristle large, next one medium size, next one large, ventrad bristle medium sized). Pleural arch well developed, strongly convex.

Legs: Procoxa with numerous bristles scattered over entire segment, ventromarginal bristles extending beyond trochanter. Mesocoxa with bristles limited to anterior marginal area; metacoxa with bristles on anterior margin and about 13 submarginal bristles on distal half; metacoxa with an oblique row of five or six spiniforms beginning at anterior margin on apical one-fifth. Profemora each with 8 to 10 thin lateral and submarginal bristles. All femora with two ventromarginal subapical bristles, both long in femur 1, markedly unequal in length in femora 2 and 3. Femora with two long, unequal, ventromarginal, subapical bristles strongly arched toward tibia. Hind tibia with about 16 lateral and sublateral bristles; six lateral notches of caudal margin with unequal spines in ratio 2:2:2:3:3:3 (base to apex); distal margin of hind tibia with a row of 3 long, 2 small, and 3 long bristles; hind tibial tooth well developed.

Abdomen: Tergum 1 with three or four scattered small bristles followed by a row of five or six larger bristles and a second row of a similar number of still larger bristles with fine intercalary bristles. Terga 2–6 typically with two rows of about eight bristles each, caudal row of large bristles and five or six small intercalaries; tergum 7 with both rows of bristles reduced in number. Sternum of abdominal segment 2 with one bristle on ventral margin; sterna 3–6 each with a row of three bristles frequently pre-



Figs. 4–5. *Meringis disparalis*: (4) apical third of aedeagus; (5) ♀ sternum 7 and spermatheca.

ceded by a single bristle; sternum 7 with a row of about four bristles preceded by two bristles. Three antepygidial bristles present; middle bristle over twice as long as upper one; ventral bristle longer than dorsal one.

Modified abdominal segments: Tergum 8 reduced in size, narrow dorsally between antepygidial bristles and sensillum, expanding ventrad to below apex of proximal arm of sternum 4; with a mesal row of eight or nine thin bristles on dorsal half. Sternum 8 large, extending dorsad to near apex of proximal arm of sternum 9 and caudad about half length of distal arm; with an irregular row of five or six median small bristles followed by a row of about five larger bristles; ventrocaudal margins of sternum 8 produced into a process which is truncate at apex. Distal arm of sternum 9 tapering to a narrow tip, but not as narrow as *bilsingi*; subapical spiniform bristle always present; usually a second distal spiniform present which is smaller and less darkly pigmented.

Immovable process of clasper comparatively slender, apical portion not as wide as movable finger; divided into two lobes of approximately same height at apex by a shallow sinus; single acetabular bristle inserted near ventrocaudal margin (bristle over twice as long as this distance). Movable process of clasper roughly rectangular in shape, with broadly rounded (almost truncate) dorsal margin; over one-third of its height extends distad of the immovable process. Cephalic margin almost straight and caudal margin gently concave; a row of 10–12 microsetae along or near cephalic margin; several thin bristles scattered over movable process; about 15 marginal and four submarginal bristles of approximately the same size along caudal margin. Manubrium about eight times as long as basal width; beyond basal third sides parallel; tip directed dorsad.

Aedeagus (Fig. 3) comparatively long and slender; median lamina over three times as long as wide, about same width throughout except for a slight constriction immediately anterior to fulcrum. Fulcrum with a curved fulcral latero-ventral lobe and a thicker, straight fulcrual medial lobe. Two strong proximally directed lateral shafts of capsule pass under medial lobes of fulcrum. Crescent sclerite well sclerotized. Armature of inner tube prominent, longer than crescent sclerite, lying above sclerotized inner tube. Median dorsal lobe, bifid, narrowing apically to ventrad-directed, subacute apex. Lateral lobes long, narrow projections of pouch wall, broadest at base, tapering gently to bluntly rounded ventrad-directed apex. Crochet well developed, much wider than lateral lobes.

FEMALE.— Outline of sternum 7 variable. Sinus shallow, but usually with a small, dorsal lobe bluntly produced; anterior row of about six bristles, posterior row of about six longer bristles present. Anal stylet about 3.5 times as long as broad, with one long apical bristle and two very small, subapical ones. Bulga of spermatheca cylindrical, both ends of approximately equal width, ventral margin almost straight and dorsal margin concave; hilla appreciably longer than bulga, about one-half as wide, sharply upturned and caudad-directed; sternum 8 reduced, three to five bristles at tapered apex. Tergum 8 large, two or three bristles near dorsal margin just posterior to three antepygidial bristles; two mesal rows of unequal bristles present, posterior row complete from dorsal to ventral margins; anterior row only on lower half; caudal margin with an irregular row of heavy bristles.

Type specimens were all collected by field personnel of the Plague Branch in New Mexico.

HOLOTYPE ♂.— Ex *Dipodomys merriami*, Dona Ana Co., 13-XII-1951.

ALLOTYPE ♀.— Ex *D. merriami*, Dona Ana Co., 12-XII-1951.

PARATYPES.— 3 ♂♂, 4 ♀♀ ex *D. merriami*, Dona Ana Co., 12-XII-1951; 2 ♂♂ ex *Onychomys leucogaster*, Dona Ana Co., 12-XII-1951; 1 ♀ ex *D. merriami*, Eddy Co., 6-III-1952; 1 ♂ ex *D. merriami*, Luna Co., 4-V-1939; 1 ♂ ex *D. merriami*, Luna Co., 19-XII-1950; 1 ♂ ex *O. leucogaster*, Luna Co., 5-V-1939; 1 ♂ ex *O. leucogaster*, Dona Ana Co., 14-IV-1939; 2 ♂♂ ex *D. merriami* Dona Ana Co., 11-XII-1951; 1 ♂ ex *D. merriami*, Luna Co., 19-XII-1950; 2 ♀♀ ex *D. merriami*, Dona Ana Co., 13-XII-1951; 1 ♂ ex *D. ordii*, Dona Ana Co., 13-IV-1939; 1 ♂ ex *D. merriami*, Dona Ana Co., 15-I-1952.

COMMENT.— This species has been most commonly taken from the kangaroo rat, *Dipodomys merriami*, in the New Mexico counties of Dona Ana, Eddy, and Luna. It has also been taken from *D. ordii* and *Onychomys leucogaster*.

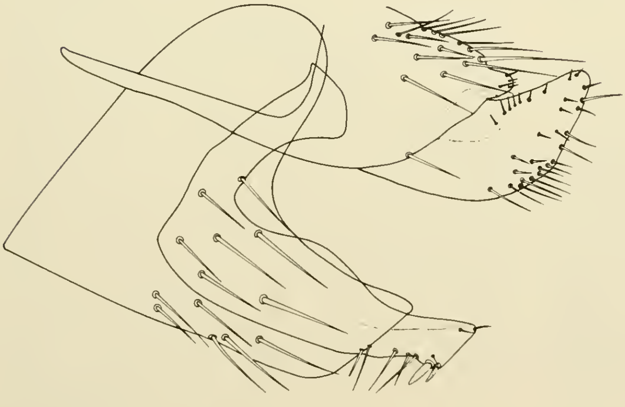
Meringis facilis, n. sp.

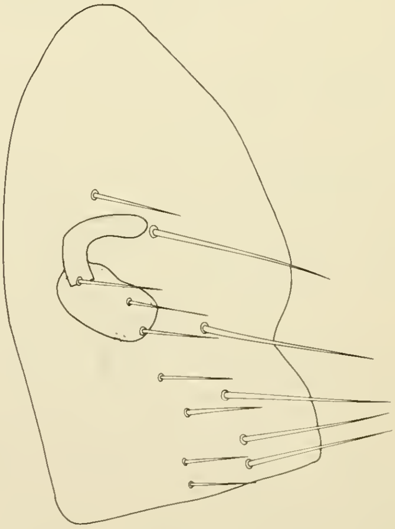
Figs. 6–9

DIAGNOSIS.— In the male, apical sinus divides the immovable process of the clasper into two markedly unequal lobes as in *M. dipodomys* and *M. bilsingi*. The short, thick (at midpoint) movable finger of the clasper (height only slightly more than twice its width) tapers to an evenly rounded, subacute apex, not at all tending to be rectangular in shape as with *M. dipodomys* and *M. disparalis*. The process of the ventrocaudal margin of sternum 8 much wider distally than in related species, wider than movable process of clasper. The distal arm of male sternum 9 extends a very short ditance beyond the insertions of the two spiniform bristles, the second and smaller of the two is on the truncate, caudal margin. In *M. bilsingi* the distal arm of sternum 9 tapers to a very narrow tip. Females are difficult to identify in the absence of males. The sinus of sternum 7 is shallow but has a definite dorsal lobe which tends to be sharply produced.

MALE.— *Head*: Frontoclypeal margin evenly rounded, with micropunctations scattered from first row of bristles to margin of head. Preantennal region with row of three thin bristles, followed by four larger bristles (dorsal bristle extends beyond inner tooth of genal comb) and an irregular row of about three microsetae. Postantennal region with micropunctations scattered anteriorly to first row of bristles; three large dermal pores and two smaller pores present; three rows of bristles arranged about 4:5:5, with ventral bristle in each row much longer; a row of about 10 fine hairs along dorsal margin of antennal fossa.

Thorax: Pronotal comb of seven large spines per side, preceded by row of six large bristles with fine intercalary bristles. Mesonotum with two rows of bristles, larger second row with fine intercalary bristles, preceded by numerous scattered small bristles; mesonotal flange with 2–4 pseudosetae per side. Mesepisternum with three unequal bristles in irregular row along pleural rod. Mesepimeron with two rows of bristles, three in first and two larger ones in second. Lateral metanotal area with irregu-


6

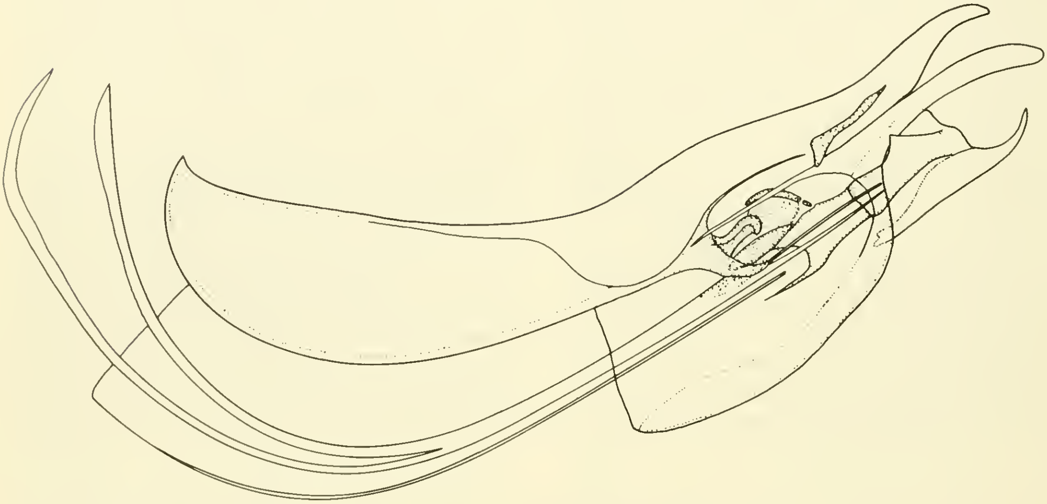

7

Figs. 6–7. *Meringis facilis*: (6) ♂ modified abdominal segments; (7) ♀ sternum 7 and spermatheca.

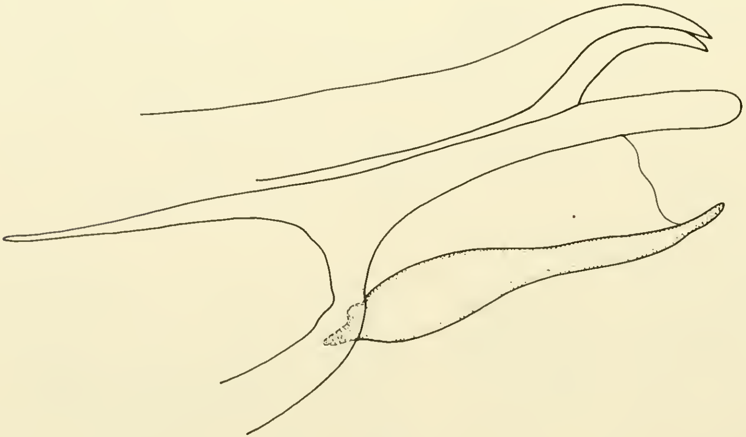
lar row of two large bristles and a small ventral bristle; metanotum with short first row of small bristles and second larger row of larger bristles; metepimeron with three rows of bristles arranged 2:3:2, last two bristles near caudal margin and much larger than others. Pleural arch well developed, strongly convex.

Abdomen: Tergum 1 with irregular row of about three small bristles, followed by row of five larger bristles and third row of five still larger ones with five intercalary bristles. Terga 2–6 typically with two rows of seven or eight bristles frequently preceded by two or three irregularly spaced bristles on cephalic segments. Abdominal sternum 2 with one bristle on ventral margin; setation of sterna 3–6 variable, typically 3–6 with row of three bristles preceded by a single bristle, sternum 7 with a row of four bristles preceded by one or two bristles. Three antepygidial bristles present.

Modified abdominal segments: Tergum 8 reduced in size, mesal row of four or five bristles, sometimes preceded by one or two bristles on dorsal third. Sternum 8 large, ex-



8



9

Figs. 8–9. *Meringis facilis*: (8) aedeagus; (9) apical third of aedeagus.

tending dorsad to apex (or beyond) of proximal arm of sternum 9 and caudad to near apex of distal arm; dorsal half narrow, about one-half width of expanded ventral half; ventrocaudal portion with patch of 13–14 unequal bristles; process of ventrocaudal margins much wider than in related species (wider than movable finger of clasper and over three times as wide as distal arm of sternum 9).

Immovable process of clasper not large, apical half about same size as movable process; divided at apex by shallow sinus into two markedly unequal lobes; large, caudal lobe with three fine bristles toward apex; small lobe with very long bristle, another ventrad of it, followed by a somewhat smaller bristle and a decidedly smaller one; dorsomarginal row of about six bristles, four submarginal ones in two irregular rows. Movable finger of clasper about 2.5 times as high as wide at midpoint, extending one-third of its length beyond immovable process of clasper; basal third of anterior margin concave, remainder fairly straight; posterior margin with apical half straight, basal half convex; anterior margin with irregular row of seven or eight submarginal setae, posterior margin with one long and three short bristles toward apex, followed by about 10 long marginal bristles; two or three long, submarginal bristles at about middle of movable finger smaller at base than marginal bristles.

Manubrium long and thin, about nine times as long as basal width, dorsal margin fairly straight, ventral margins sinuous, tapering somewhat to subacute, dorsad-directed tip. Sternum 9 with proximal arm much shorter and thinner than distal arm, widest toward somewhat swollen, evenly convex apex, dorsocephalic margins forming a beak; distal arm with sinuous, dorsal margin, ventral margin rather straight with shallow concavity toward apex; one large subapical spiniform on ventral margin, usually a smaller, lighter spiniform on caudal margin; distal arm distinctively broad and truncate at apex (only *deserti* shares this character).

Aedeagus (Figs. 8–9) with sclerotized inner tube long and slender (length three times basal width) and with little flaring at apex; conspicuous spur of dorsal margin at about midpoint rather than usual basal one-fifth to one-third; in *facilis* resulting shallow sinus almost one-half length of tube; lateral lobe long and slender (length five times basal width) extending beyond tips of median dorsal lobe and crochets, subacute at ventrad-directed tip; at base dorsal arm exceptionally long, proximal extension beyond fulcral-ventral lobe.

FEMALE.— Outline of sternum 7 variable. Shallow sinus produces a large, evenly rounded dorsal lobe; anterior row of seven to nine bristles in an irregular row occasionally preceded by one or two bristles, and a posterior row of five or six large bristles. Anal stylet short, 2.5 times as long as basal width, with a long apical and two very small subapical bristles. Spermatheca noticeably larger than is usual in *arachis*-group; bulga cylindrical, ventral margin fairly straight, dorsal margin concave, about twice as wide as hilla; hilla about same length as bulga, sharply upturned and directed caudad.

HOLOTYPE ♂ AND ALLOTYPE ♀.— Ex *Dipodomys ordii*, Chaves Co., New Mexico, 14-XII-1966, J. Wheeler.

PARATYPES.— Colorado: 1 ♂ ex *D. ordii*, Crowley Co., 23-V-1970, E.G. Campos. New Mexico: 3 ♂♂ ex *Onychomys leucogaster*, Chaves Co., 20-XI-1968, J. Wheeler; 2 ♂♂ ex *Neotoma micropus*, Chaves Co., 6-XII-1967, J. Wheeler; 2 ♂♂ ex *Perognathus flavus*, Chaves Co., 23-III-1967, J. Wheeler; 1 ♂ ex *O. leucogaster*, Chaves Co., 8-XI-1968, J. Wheeler; 3 ♂♂, 2 ♀♀ ex *O. leucogaster*, Chaves Co., 6-XII-1967, J. Wheeler; 1 ♂ ex *O. leucogaster*, Bernalillo Co., 8-XI-1950, Frank Prince; 1 ♂ ex *O. leucogaster*, Valencia Co., 26-IV-1939, Frank Prince; 1 ♂, 1 ♀ ex *D. ordii*, Chaves Co., 14-XII-1966, J. Wheeler.

COMMENT.— This species was most commonly taken from the kangaroo rat, *Dipodomys ordii*; it has also been taken from a variety of rodents, and one species of rabbit (*Sylvilagus audubonii*) associated with *D. ordii*. It is prevalent on *Onychomys leucogaster*. Specimens were found in the southeastern Colorado county of Crowley and the New Mexico counties of Bernalillo, Chaves, and Valencia.

Key to *Meringis* Males

1. Distal arm of sternum 9 bilobed, each lobe bearing apical bristle usually strongly spiniform; membranous flap projecting beyond margin of sternum 9 between two lobes 2

Distal arm of sternum 9 not bilobed, ventral lobe lacking; no membranous flap projecting from ventral margin of sternum 9 6

2(1). With three antepygidial bristles 3

With two antepygidial bristles 4

3(2). Lower lobe of each arm of median dorsal process of phallosome truncate at apex, apical width of lobe about one-third basal width (widely distributed in western states) .... *parkeri*

Lower lobe of each arm of median dorsal process of phallosome evenly rounded at apex, apical width more than half basal width (recorded from California and Nevada) .... *californicus*

4(2). Subapical spiniform bristle of sternum 9 accompanied by two subspiniform bristles (Washington, Oregon, British Columbia) .... *shannonii*

Subapical spiniform bristle of sternum 9 not accompanied by bristles with tendency to be spiniform 5

5(4). Subapical spiniform bristle of sternum 9 short, less than one-third length of adjacent bristle .... *hubbardi*

Subapical spiniform bristles of sternum 9 over one-third length of adjacent bristles .... *jamesoni*

6(1). Pronotum about twice as wide dorsally as ventrally, comb strongly curved .... *altipectin*

Pronotum about equal width dorsally and ventrally, comb straight 7

7(6). Distal arm of sternum 9 regularly tapered to a very narrow tip; usually with only 1 subapical spiniform bristle, three or four bristles on lateral surface of movable finger of clasper larger in basal diameter than marginal bristles .... *bilsingi*

Distal arm of sternum 9 sharply angled or broadly rounded at tip; usually with two subapical spiniform bristles; if lateral bristles present on movable finger of clasper, then bristles not larger in basal diameter than those at margin 8

8(7). Anterior margin of movable process of clasper concave preapically .... *nidi*

Anterior margin of movable process of clasper straight preapically 9

9(8). Process of ventrocaudal margin of sternum 8 produced at an acute angle, toward apex not as wide as distal arm of sternum 4 .... *deserti*

Process of ventrocaudal margin of sternum 8 not acuminate, toward apex as wide or wider than distal arm of sternum 9 10

10(9). Movable process of clasper slender throughout, over three times as high as wide .... *cummingi*

Movable process of clasper less than 3 times as high as wide 11

11(10). Process of ventrocaudal margin of sternum 8 distally wider than movable process of clasper .... *facilis*

Process of ventrocaudal margin of sternum 8 distally less than half width of movable process of clasper 12

12(11). Distal arm of sternum 9 broader than movable process of clasper 13
Distal arm of sternum 9 not more than half as wide as movable process of clasper 14

13(12). Crochet with dorsal margin distinctly concave, apex acute and slightly upturned .... *arachis*
Crochet with dorsal margin straight or slightly convex blunt and not slightly upturned .... *rectus*

14(12). Movable process of clasper about twice as high as greatest width .... *vitabilis*
Movable process of clasper more than twice as high as greatest width 15

15(14). Apical sinus divides immovable process of clasper into two markedly subequal lobes .... *dipodomys*
Apical sinus divides immovable process of clasper into two lobes of about equal height 16

16(15). Process of ventrocaudal margin of sternum 8 evenly rounded at apex .... *agilis*
Process of ventrocaudal margin of sternum 8 truncate at apex .... *disparalis*

ACKNOWLEDGMENTS

I thank Mr. Garth N. Graves, Program Manager, Vector Control Program, Environmental Improvement Agency, New Mexico Health and Social Services Department, Sante Fe, for making available some of the material utilized in these descriptions. Appreciation is also expressed to my esteemed colleague, Mr. Edward Campos, Plague Branch, Vector-Borne Diseases Division, for his encouragement and assistance.

ABBREVIATIONS

A.E.P.	Aedeagal pouch
A.I.T.	Armature of inner tube of aedeagus
B.	Bulga (head) of spermatheca
COX. I	Procoxa
COX. 2	Mesocoxa
CR.	Crochet
C.S.	Crescent sclerite of aedeagus
C.V.P.	Caudoventral process
D.A. 9	Distal arm of sternum 9
D.P.R.	Dorsal penis rod
FUL.	Fulcrum of aedeagus
FUL. L.L.	Fulcral lateroventral lobe of aedeagus
FUL. M.L.	Fulcral medial lobe of aedeagus
H.	Hilla (tail) of spermatheca
I.P.C.	Immovable process of clasper
L.L.	Lateral lobe of aedeagus
L.S.C.	Lateral shaft of capsule of aedeagus
M.D.L.	Median dorsal lobe of aedeagus
M. LAM.	Middle lamina of aedeagal apodeme
M.P.C.	Movable process of clasper
P.A. 9	Proximal arm of sternum 9
SAT. S.	Satellite sclerite of aedeagus
S.I.T.	Sclerotized inner tube of aedeagus
V.P.R.	Ventral penis rod
7 S.	Sternum 7
8 S.	Sternum 8
9 S.	Sternum 9

THE EFFECTS OF RADIATION FROM URANIUM MILL TAILINGS ON *TRADESCANTIA*[1]

E. A. Rechel[2] and W. F. Campbell[3]

Abstract.— To assess the potential hazard from radioactive wastes, a plant with known radiosensitivity, *Tradescantia* clone 02, was grown in radioactive soil obtained from uranium mill tailings. The levels of radiation on these tailings varied from 0.03mR/hr (background) to a maximum of 3.00 mR/hr. *Tradescantia* grown in soil with a radiation level greater than 0.10 mR/hr evidenced significantly reduced reproductive integrity and fecundity, as measured by the number of stunted hairs per stamen, pollen viability, and numbers of somatic mutations. Based on these data, the radioactivity from uranium mill tailings has the potential to alter normal plant succession due to its detrimental effect on any species that is relatively radiosensitive.

An increase in atomic power as a source of domestic energy will lead to increased levels of ambient radiation locally. Uranium mill tailings are a case in point: there environmental contamination by various radionuclides may occur many years after a mill has shut down (Sears et al. 1975). This radioactivity may not only contaminate surrounding terrestrial and aquatic communities (Pendleton et al. 1964, Sears et al. 1975), but any species colonizing these tailings will have to contend with a radiation level-exceeding background. The radiosensitivity of colonizing species may ultimately determine plant succession patterns.

Tradescantia demonstrates an extreme sensitivity to ionizing radiation, i.e., it is highly radiosensitive (Sparrow, Underbrink, and Sparrow 1967, Sparrow, Underbrink and Rossi 1972). The ability of this plant to respond to differing levels of ionizing radiation and its effects can be seen in the work by Mericle and Mericle (1965a,b), Ichikawa and Sparrow (1968), and Underbrink, Schairer, and Sparrow (1973). In this study, *Tradescantia* was used to evaluate potential effects of low-level chronic radiation on plant succession. The specific hypothesis to be tested was: levels of ionizing radiation emitted from uranium mill tailings have the potential to increase somatic mutations and to decrease pollen viability and overall reproductive integrity of radiosensitive species colonizing the tailings.

Materials and Methods

Soil samples from five sites on the Vitro Chemical Plant (located at 3300 South 900 West, Salt Lake City, Utah) mill tailings were collected in 1975. The levels of activity at the sites from where our soil samples were taken were 1.11, 1.62, 2.04, 2.72, and 3.32 mR/hr with the latter representing the highest radiation level detected on the tailings. The control had an activity of 0.01 mR/hr. After transporting the tailings from the Vitro Mill site to the greenhouse, the amount of ionizing radiation was measured using a Victoreen Thyac III survey meter in the absence of the Vitro radiation field. The new levels were 0.07, 0.10, 0.14, 0.20, and 0.19 mR/hr, respectively, with the control remaining at 0.01mR/hr.

Tradescantia, clone 02 (obtained from A. H. Sparrow, Brookhaven National Laboratory), was used as the test species. Clone 02 is a perennial, herbaceous, diploid plant (2n = 12), with narrow tapering leaves (not unlike some medium-sized grasses), and reaches a height of about 60 cm. It is heterozygous for blue and pink flower color and is thought to be a hybrid between *T. occidentalis* and *T. ohiensis* (Sparrow et al. 1961).

---

[1] Contribution from the Plant Science Department and the Utah Agricultural Experiment Station as Paper 2343. We thank R. Pendleton, R. L. Smith, and Lois Cox for critical review of the manuscript.

[2] Department of Biology, Utah State University, Logan, Utah 84322.

[3] Plant Science Department, Utah State University, Logan, Utah 84322.

Thirty-six plants of equal size and containing young infloresecenses were selected from a stock population. Root systems were washed in water to remove soil. Each treatment consisted of six plants repotted in either radioactive tailings from one of the five sites or the control soil. Plants were grown under greenhouse conditions with a 16-hr light cycle, a day temperature of 35 C, and a night temperature of 20 C. The pH of all radioactive tailings was adjusted to that of the control soil (pH 8.0) with $CaCO_3$. A nutrient solution was added to each pot once every five days through the first two weeks (Blankedaal et al. 1972). Plants at each radiation level were separated by 30 cm on the same greenhouse bench, and those in the control soil were located in an adjacent room.

Ten days after the plants had been potted, data were collected for 20 continuous days on the number of stunted hairs, somatic mutations per stamen, and percent pollen viability. The 10-day lag period served two purposes: 1) it allowed the plants to recover from the shock of transplanting, and 2) effects of radiation treatment are normally not seen for one week to 10 days (Ichikawa and Sparrow 1967, Underbrink et al. 1970). A maximum of four flowers were chosen randomly from each treatment group each day, and from each of these flowers one stamen was chosen at random for scoring. An arbitrarily chosen antipetalous stamen was numbered as one, with the next stamen in a clockwise direction being two, and the next three. The antisepalous stamen located between stamen one and two is designated four, with five and six located in a similar clockwise manner. The selected stamen was then divided into three arbitrary regions for ease of scoring. The types of somatic aberrations scored were blue to pink, blue to colorless, pink to colorless, colorless to pink, normal size cell to giant or dwarf, and branched hairs (Underbrink et al. 1973). Loss of reproductive integrity in stamen hairs was measured by the number of stunted hairs (Ichikawa and Sparrow 1967, 1968). An average hair from a healthy plant consists of 20.5 cells, and a stunted hair has been defined as one with 12 cells or less (Ichikawa and Sparrow 1967, Underbrink et al. 1973).

Reproductive integrity is the ability of somatic tissue to achieve the number of mitotic cycles characteristic of the species that lead to its natural size and shape. The number of stunted hairs has been correlated with reproductive integrity by demonstrating that these hairs do not obtain their normal length due to a slowing or complete cessation of the mitotic cycle (Ichikawa and Sparrow 1968). Pollen viability was determined by randomly selecting two of the four flowers previously picked and smearing five anthers on a slide to release the pollen grains. The pollen was then stained with acetocarmine. Viable pollen absorbs this stain and the nucleus appears red; aborted pollen remains yellow. Data were recorded as percent viable and nonviable pollen. Each parameter was subjected to an analysis of variance using a completely randomized design followed by statistical comparisons for locating significant differences among the treatments.

Radiation source analysis

Nayar, George, and Gopan-Ayengar (1970) have shown that the ionizations from radionuclides in radioactive monazite sand that were absorbed by roots of *Tradescantia* were more effective than external radiation in increasing the frequency of somatic mutations. A similar experiment was conducted with a tailings sample from the Vitro Mill. The purpose was to determine whether differences in the number of somatic mutations per stamen, stunted hairs per stamen, and pollen viability were due to internally absorbed radionuclides or to external ionizations.

Six plants of equal size and containing young inflorescences were potted in soil with a background radiation level of 0.01 mR/hr. A plastic bag was placed around each plot and all six arranged in a small wooden enclosure. Mill tailings from the 0.19 mR/hr treatment were then evenly distributed around the six plants. In both experiments, the treated plants were exposed to equal amounts of radioactive tailings. Six control plants were potted in soil with a background radiation level of 0.01 mR/hr and located in an adjacent room. All plants were grown in a glasshouse. Ten days after potting, data were collected on mutations per stamen, stunted hairs per stamen, and percent pollen viability for 15 consecutive days in a manner similar to that described above. The data were analyzed with Student's t-test.

Results

Average numbers of mutations per stamen for each level of radiation are presented in Figure 1. An analysis of variance (ANOV) revealed significant differences between treatments: statistical comparisons revealed where the differences occurred. Three subsets appeared within the six radiation treatments. A linear regression analysis with adjusted treatment means demonstrated a significant correlation, ($r = .78$ and $r^2 = .62$) between radiation level and number of mutations per stamen.

Figure 2 shows the average number of stunted hairs per stamen for each treatment. Again, a significant difference was shown by the ANOV test. Three major subsets were apparent, with different treatments appearing in more than one subset. A linear regression, using adjusted means, indicated that a significant correlation ($r = .88$ and $r^2 = .77$) existed between radiation level and number of stunted hairs per stamen.

Pollen viability ratings, averaged for each treatment, are shown in Figure 3. Analysis of variance identified a significant difference between the different radiation levels. The statistical comparisons grouped the six treatments again into three subsets. There was some overlapping of subsets among the treatments. The linear regression of radiation level versus pollen viability was not significant.

The results from the radiation source analysis experiment are presented in Table 1. There were no significant differences between the control and treated plants in the number of mutations per stamen, stunted hairs per stamen, or pollen viability.

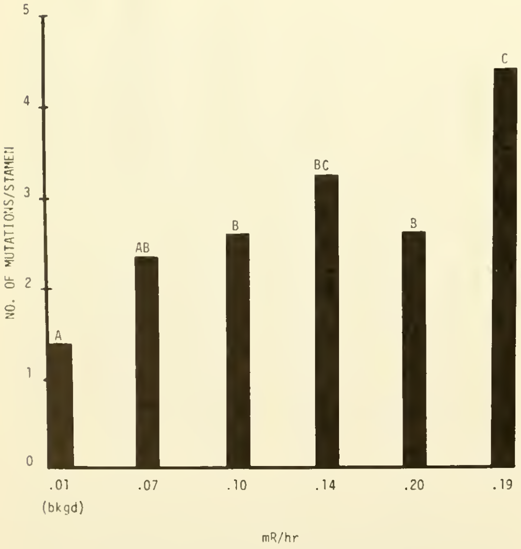


Fig. 1. Mutations per stamen in *Tradescantia* clone 02, as affected by ionizing radiation from radioactive mill tailings. Columns with the same letter above are not significantly different.

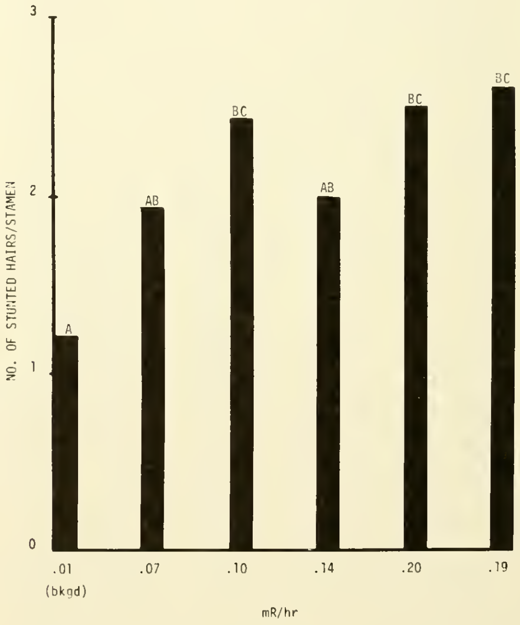


Fig. 2. Stunted hairs per stamen in *Tradescantia* clone 02, as affected by ionizing radiation from radioactive mill tailings. Columns with the same letter above are not significantly different.

DISCUSSION

Early studies conducted by Sparrow and Pond (1956), using two *Antirrhinum* clones, demonstrated that exposure levels of 16mR/hr significantly increased mutation rates. They also suggested that much lower doses also increased mutations.

A more comprehensive analysis, correlating low-level radiation and its effect on the stamen hairs of *Tradescantia* clone 02, has been conducted by Mericle and Mericle (1963, 1965a,b). Their procedure involved exposing plants to geological dikes where the radioactivity was two to five times higher than normal. They detected significant changes in the number of somatic mutations and stunted hairs per stamen at 0.10 and 0.25 mR/hr. Since the plants were potted in normal soil this increase was attributed primarily to external radiation.

Results of this study closely paralleled those obtained by Mericle and Mericle (1963). All plants subjected to 0.10 mR/hr and above differed significantly from the control plants. The only exception was in the number of stunted hairs per stamen. Here, plants subjected to 0.10 mR/hr were statistically distinct from the controls, but plants grown in soil at 0.14 mR/hr showed no significant difference from the controls. Although there appeared to be variations throughout the six treatments in the number of mutations and stunted hairs per stamen, the trend was for an increase as radiation increased. Pollen viability, however, did not show a significant correlation with increasing radiation, although viability did decrease when the comparisons involved the two extremes (Fig. 3). In contrast to the studies by Mericle and Mericle (1965a,b), we found no disparity in the qualitative analyses of the stamen hairs or pollen from 0.10 mR/hr to the highest treatment levels (0.20 and 0.19 mR/hr). The present study also revealed that plants grown in the 0.07 mR/hr soil were similar to the control plants. Thus, the critical dosage in this study seemed to lie between 0.07 and 0.10 mR/hr.

The data from the *Tradescantia* stamen hairs and pollen support our hypothesis, but only relative to plants with a high radiosensitivity. Stated in another way, species characterized by low radioresistance, e.g., *Tradescantia* clone 02, would have to adjust to an increase in somatic mutations, and a decrease in reproductive integrity and pollen viability, when growing on the radioactive mill tailings from the Vitro Chemical Plant.

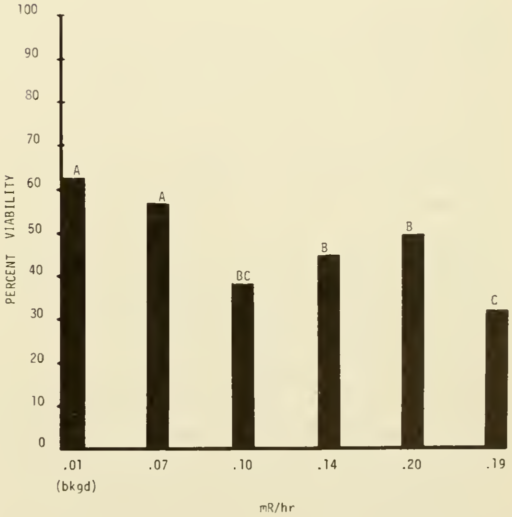


Fig. 3. Pollen viability in *Tradescantia* clone 02, affected by ionizing radiation from radioactive mill tailings. Columns with the same letter above are not significantly different.

TABLE 1. Student's t test for comparing stamen hairs and pollen from *Tradescantia* which were subjected to an external radiation dose of 0.18 mR/hr or 0.01 mR/hr.

	Averages			
Parameter	Control (0.01 mR/hr)	Treatment (0.18 mR/hr)	d.f.	t Value
Somatic mutations per stamen	2.31	2.44	68	0.19
Stunted hairs per stamen	1.42	1.32	68	0.24
Pollen viability (percent)	44.76	49.13	22	0.88

The radiation source experiment was an attempt to verify the origin of the ionizations that contributed to the change in mutation rate, reproductive integrity, and pollen viability in *Tradescantia* clone 02. Our data suggest that the source was internal. This contradicts the results of Mericle and Mericle (1965a), though absorption of radioactive radon gas through the leaves could not be eliminated as a possibility. In the present study, all internal radiation must have been a product of root absorption. Mistry et al., (1965) and D'Souza and Mistry (1970) examined the uptake of various radionuclides by plants inhabiting radioactive monazite sand and those growing in hydrosolutions. Radius-226 was transported more readily and it accumulated in higher concentrations in stems and leaves of treated plants than did any other radionuclide. Plants can, however, absorb other radionuclides such as uranium-238, thorium-230, lead-210, and polonium-210 (Dinse and LaFrance 1953, D'Souza and Mistry 1970). The ionizing radiation from the Vitro Chemical Plant mill tailings is due, in part, to these same elements, which represent the uranium decay series (Sears et al. 1975). *Tradescantia* may have absorbed radionuclides through its root system, and these nuclides may have caused the internal ionizations, with perhaps radium-226 the predominant isotope involved.

Levels of radiation measured in the greenhouse were considerably lower than those recorded on the mill tailings. If it had been possible to grow these plants on the site, the differences between treatments and controls might have been more pronounced (Nayer and Sparrow 1967, Ichikawa 1971). The decrease in ionizing radiation may have been caused by a decline in the amount of radioactive radon gas, a member of the uranium decay series. Radon gas is reportedly trapped in the soil layers by any mechanism that tends to seal the surface (Osburn 1965), e.g., a lack of vegetation or very little precipitation. Pendleton (pers. comm.), however, has indicated that radon gas is very poorly trapped in soil layers. Transferring the tailings to the glasshouse disturbed the layers, thus the radon gas may have been released resulting in a decrease in activity. A second probable cause was that only small volumes of soil were sampled in the glasshouse whereas large volume of soil contributed ionizing particles at the Vitro Mill site.

Radiological surveys taken on the five radioactive soils as they existed in the greenhouse revealed that the two samples with the most radiation were approximately equal in activity, whereas in the field there was a much larger difference. Reasons for the initial gross decrease have already been discussed. Subtle similarities and variations are related to the Vitro Chemical Plant and its milling operations. First, ore for the mill was appropriated from numerous mines and is thus composed of several different mineral types. Second, the procedure for extracting the uranium was altered in 1956; thus the soil texture and its chemical makeup varied from one site to another. This affects the presence and availability of numerous radionuclides via differential leaching rates on different soil types. Consequently, the radioactivity in soil samples will vary, and the degree to which radionuclides are available to the plants will differ (Osburn 1965, Prokhorov 1973). These factors help explain the similarity between the two with the most radiation.

Although the radiation levels from the tailings of the Vitro Chemical Plant caused detrimental effects in *Tradescantia* stamen hairs, one must realize that not all plant species exhibit this degree of radiosensitivity, especially when the stamen hairs themselves are more sensitive to radiation than the rest of the plant (Sparrow and Schwemmer 1974). A species may possess one of many physiological and morphological attributes that will allow it to exist in an environment subjected to above normal radiation levels, e.g., nutritional state, growth hormone concentrations, plant size, and depth of roots, time requirement for mitosis and meiosis, percentage of cells dividing in the meristem, and, most importantly, interphase chromosome volume (ICV) (Gunken and Sparrow 1961). However, radioactive uranium mill tailings, which represent a source of low-level chronic radiation, are a potential hazard to any species trying to establish on these soils.

If the species has a relatively high radioresistance, it will not be affected by the radiation. The other possibilities are a lower fecundity, a higher somatic mutation rate, and a decrease in reproductive integrity. These three aspects, working together, would decrease the competitive ability of a radiosensitive population and thus alter its chances of becoming successfully established. Only the more radioresistant species will be able to colonize such sites. Succession on radioactive uranium mill tailings, over a long period, therefore, may not proceed in the same direction or at the same rate as on a similar area lacking radiation stress. And with low-level radiation, the change will not be apparent until succession has proceeded to the point where the natural turnover time in species composition is greater than the time required for radioselection to be efficient.

Literature Cited

Blankedaal, M., R. H. Hodgson, D. G. Davis, R. A. Hoerauf, and R. H. Shimabukuro. 1972. Growing plants without soil for experimental use. U.S. Dept. Agr. Misc. Publ. 1252. 17 pp.

Dinse, A. G., and L. J. LaFrance. 1953. Biological effects of uranium: literature review, pp. 2257–2269. *In*: C. Voegtlin and H. C. Hodges, eds., Pharmacology and toxicology of uranium compounds. McGraw Hill Co., New York.

D'Souza, T. J., and K. B. Mistry. 1970. Comparative uptake of thorium-230, radium-226, lead-210 and polonium-210 by plants. Radiat. Botany 10:293–295.

Gunckel, J. E., and A. H. Sparrow. 1961. Ionizing radiations: biochemical, physiological, and morphological aspects of their effects on plants. Encycl. Plant Physiol. 16:555–611.

Ichikawa, S. 1971. Somatic mutation rate at low levels of chronic gamma-ray exposures in *Tradescantia* stamen hairs. Jpn. J. Genet. 46:371–381.

Ichikawa, S., and A. H. Sparrow. 1967. Radiation-induced loss of reproductive integrity in the stamen hairs of *Tradescantia blossfeldiana* Mildbr., a twelve-ploid species. Radiat. Botany 7:333–345.

———. 1968. Radiation-induced loss of reproductive integrity, morphologically abnormal cells, and somatic mutations in *Tradescantia* stamen hairs. Proc. Int. Congr. Genet. 1:108.

Mericle, L. W., and R. P. Mericle. 1963. Is mutation rate significantly altered by five-fold differences in natural background radiation? Radiat. Res. 19:185. (Abstr.)

———. 1965a. Reassessing the biological role of background terrestrial radiation as a constituent of the natural environment. Health Phys. 11:1607–1620.

———. 1965b. Biological discrimination of differences in natural background radiation level. Radiat. Botany 5:475–492.

Mistry, K. B., A. R. Gopal-Ayengar, and K. G. Bharathan. 1965. On the radioactivity of plants from the high radiation areas of the Kerala Coast and adjoining regions. II. Studies on the uptake of alpha and gamma emitters. Health Phys. 11:1459–1470.

Nayar, G. G., K. P. George, and A. R. Gopal-Ayengar. 1970. On the biological effects of high background radioactivity: Studies on *Tradescantia* grown in radioactive monazite sand. Radiat. Botany 10:287–292.

Nayar, G. G., and A. H. Sparrow. 1967. Radiation-induced somatic mutations and the loss of reproductive integrity in *Tradescantia* stamen hairs. Radiat. Botany 7:257–267.

Osburn, W. S. 1965. Primordial radionuclides: Their distribution, movement, and possible effect within terrestrial ecosystems. Health Phys. 11:1275–1295.

Pendleton, R. C., R. D. Lloyd, C. W. Mayd, D. Atherton, and N. V. Chamberlain. 1964. Radium contamination at the Jordan River delta on the Great Salt Lake. J. Water Pollution. Control Fed. July:925–927.

Prokhorov, V. M. 1973. Ion diffusion in soils and its role in radionuclide migration pp. 103–104. *In*: V. M. Klechkovskii, G. G. Polikarpov and R. M. Aleksakhin, eds., Radioecology. John Wiley and Sons, New York.

Sears, M. B., R. E. Blanco, R. C. Dahlman, G. S. Hill, A. D. Ryon, and J. P. Witherspoon. 1975. Correlation of radioactive waste treatment costs and the environmental impact of waste effluents in the nuclear fuel cycle for use in establishing "as low as practicable" guides—milling of uranium ores. U.S. Dept. Com. ORNL-TM-4903, Springfield.

Sparrow, A. H., R. L. Cuany, J. P. Miksche, and L. A. Schairer. 1961. Some factors affecting the responses of plants to acute and chronic radiation exposures. Radiat. Botany 1:10–34.

Sparrow, A. H., and V. Pond. 1956. Some cytogenetic and morphogenetic effects of ionizing radiation on plants. pp. 125–139. *In*: A Conf. on radioactive isotopes in agriculture. AEC Bull. TID-7512.

Sparrow, A. H., and S. S. Schwemmer, 1974. Correlations between nuclear characteristics, growth inhibition, and survival-curve parameters (LD_n, whole plant D_0 and D_g) for whole-plant gamma-irradiation of herbaceous species. Intern. J. Radiat. Biol. 25:556–581.

Sparrow, A. H., A. G. Underbrink, and R. C. Sparrow. 1967. Chromosomes and cellular radiosensitivity: 1. The relationship of D_0 to chromosome volume and complexity in seventy-nine different organisms. Radiat. Res. 32:915–945.

UNDERBRINK, A. G., L. A. SCHAIRER, AND A. H. SPARROW. 1973. *Tradescantia* stamen hairs: A radiobiological test system applicable to chemical mutagenesis, pp. 171–207. *In*: A. Hollaender, ed., Chemical mutagens: principles and methods for their detection. Phlenum Press Publ. Co., New York.

UNDERBRINK, A. G., R. C. SPARROW, A. H. SPARROW, AND H. H. ROSSI. 1970. Relative biological effectiveness of X-rays and 0.43 MeV monoenergetic neutrons on somatic mutations and loss of reproductive integrity in *Tradescantia* stamen hairs. Radiat. Res. 44:187–203.

CONTRIBUTIONS TO THE BIOLOGY OF THE WOUNDFIN, *PLAGOPTERUS ARGENTISSIMUS* (PISCES: CYPRINIDAE), AN ENDANGERED SPECIES

Jeffrey N. Cross[1]

Abstract.— The woundfin is a small, streamlined, omnivorous cyprinid that is now limited to the Virgin River basin where it was collected in the mainstream and one tributary during the present study. The woundfin occurred most frequently in runs and over sand substrates and less frequently in riffles and over rock substrates. It was common over at least half of its original range within the Virgin River. It was uncommon in the lower mainstream due to habitat alterations and, presumably, predation by and competition with exotic species.

The woundfin belongs to a unique tribe of cyprinids, the Plagopterini, that is characterized by spinous modifications of the anterior dorsal and pelvic rays (Miller and Hubbs 1960). It is a small (<75 mm SL), scaleless, torpedo-shaped fish with large fins, a pair of barbels on the lips, and reduced eyes. Deacon and Minckley (unpubl. mans.) estimate the maximum age to be four years, but most individuals probably do not exceed two years.

At one time the woundfin probably inhabited the larger streams of the lower Colorado River basin (Minckley 1973). It was last collected in the Gila River basin (Arizona) in the 1890s (Miller and Hubbs 1960). It is now limited to the mainstream of the Virgin River and one of its tributaries. The purpose of the present study was to determine the distribution, general ecology, and status of woundfin populations in the Virgin River basin.

Study Area

The Virgin River heads in the Colorado Plateau geologic province in southwestern Utah. It flows southwesterly into the Basin and Range geologic province and empties into Lake Mead 320 km from its source. Prior to the construction of Hoover Dam (1935), the Virgin River discharged directly into the Colorado River. The climate of the Virgin River basin is arid to semiarid, with mild winters, hot summers, and high evaporation rates. The river is characterized by widely variable discharges and high sediment loads.

Methods

Fish were collected with tied nylon minnow seines (3.0, 3.7, 4.6, and 6.1 m long by 1.2 and 1.8 m deep with 3 and 6 mm mesh) between 21 June 1973 and 15 March 1975. Each station (Fig. 1) was sampled with three consecutive seine hauls within each habitat type (run, riffle, or pool). Fish were maintained in 19 liter buckets until sampling was completed and returned alive to the streams. A few specimens were returned to the laboratory preserved in 10 percent formalin.

At each station the following data were collected: water temperature, conductivity, current velocity, stream width, depth of capture, average depth of the habitat, and length of the seine haul.

Fish returned to the laboratory were left in formalin five days, washed in water two days, and stored in 65 percent ethanol. A sterioscopic dissecting microscope was used to examine gut contents. Specimens are housed in the Department of Biological Sciences, University of Nevada, Las Vegas.

---

[1] Department of Biological Sciences, University of Nevada, Las Vegas, Las Vegas, Nevada 89154. Present address: Fisheries Research Institute, College of Fisheries, University of Washington, Seattle, Washington 98105.

Results

The woundfin was collected in the mainstream Virgin River from Riverside, Nevada, upstream to LaVerkin Springs (=Virgin Springs), Utah, and in the lower reaches of LaVerkin Creek (Fig. 1). It was the most abundant of the native species; 5,000 out of 10,822 native fish collected were woundfin. Woundfin occurred in 33 percent of the collections in the lower mainstream (downstream from Mesquite, Nevada) and made up from 30 to 100 percent of the catch but averaged less than 50 percent. In the middle reaches of the mainstream (downstream from Hurricane, Utah) the woundfin was present in 90 percent of the collections and generally comprised 50 percent of the catch. In the upper mainstream it occurred in 65 percent of the collections and averaged less than 33 percent of the catch. The woundfin was present in all collections in the lower reaches of LaVerkin Creek and generally comprised less than 50 percent of the fish fauna.

The woundfin occurred most frequently in runs (75 percent of all collections), less frequently in riffles (20 percent), and occasionally in pools (5 percent). It was collected over sand (60 percent of all collections), rubble and cobble (30 percent), and mud (10 percent) substrates. The mean depth of capture was 43 cm (SE = 13.3, n = 38); the average depth of the water was 25 cm (SE = 6.2, n = 38). In one-half of the collections, woundfin were associated with some type of cover, usually overhanging deadfalls, brush, or trees. Water temperatures ranged from 10.0 to 35.5 C with a mean of 23.7 C (SE = 2.3, n = 38). Conductivities ranged from 150 to 2650 μmhos (at 25 C) with a mean of about 1100 μmhos. Current velocities ranged from zero to 1.13 m/sec with a mean of 0.42 m/sec (SE = 0.09, n = 38). In more than 60 percent of the collections woundfin occurred in habitats that were

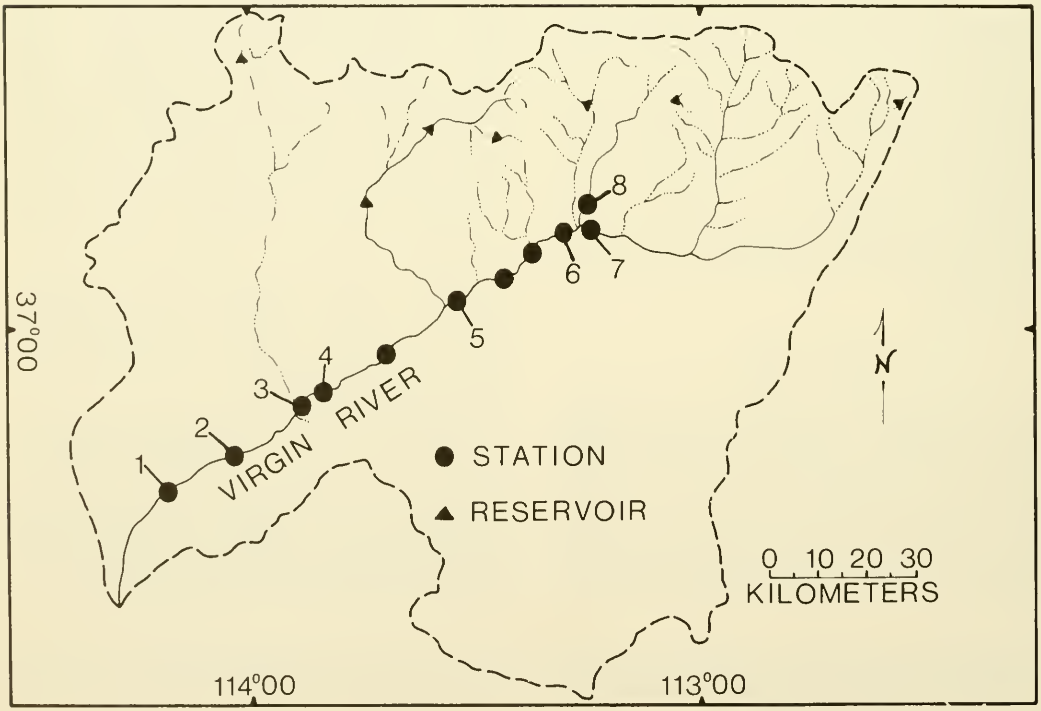


Fig. 1. Map of the Virgin River showing collection localities: (1) Riverside, Nevada; (2) Mesquite, Nevada; (3) Littlefield, Arizona; (4) Arizona Narrows, Arizona; (5) St. George, Utah; (6) Hurricane, Utah; (7) LaVerkin Springs, Utah; (8) LaVerkin Creek, Utah.

considered to be physically unmodified; in the remaining collections it occurred in habitats considered to be moderately to largely modified (irrigation withdrawals and return flows, organic wastes, stream channelization). Native fishes (Table 1) comprised an average of 89 percent (SE = 7.1, n = 38) of collections containing the woundfin.

The spawning habitat and reproductive behavior of the woundfin are not known. Ripe, tuberculated individuals were collected in May. Spawning appeared to commence about April to May and continued through August (Lockhart, unpubl. mans.). Young-of-the-year were collected from early June to mid-August. Juvenile woundfin occupied shallow areas lateral to the main current. When water levels were low, juvenile woundfin often occurred in the main channel.

Woundfin possess a poorly defined stomach occupying about one-fifth of the total gut length. Examination of 14 specimens collected in August partly at Littlefield and partly at the mouth of LaVerkin Creek produced the following items (in order of abundance): sand grains, aquatic insect larvae (predominantly dipterans), filamentous green algae, plant debris, terrestrial insects (mainly ants) and amphipod larvae.

In laboratory aquaria (39 and 208 liters), woundfin initially exhibited no evidence for visual selection of food. Soon after dried foods were introduced into the aquaria, woundfin began milling excitedly over the bottom. Within one month most individuals had begun rising to the surface to feed.

DISCUSSION

DISTRIBUTION.— Within the Virgin River system the woundfin is limited in its upstream distribution by the highly saline LaVerkin Springs (conductivity approximately 15,000 μmhos at 25 C), which enter the river along the Hurricane Fault east of LaVerkin, Utah (Fig. 1). Absence of the woundfin from the river upstream from the springs may be due to the order of appearance of the woundfin in the Virgin River and crustal movement along the Hurricane Fault. Uplift of the Unikaret Plateau (part of the North Rim of the Grand Canyon bounded on the west by the Hurricane Fault) during the Pliocene to Pleistocene could have led to the emergence of LaVerkin Springs (Cook 1960, McKee et al. 1967). Subsequently, the Virgin River may have been invaded by the woundfin, a lower Colorado River basin endemic; its upstream penetration was limited by LaVerkin Springs. The Virgin River roundtail chub is also limited in its upstream distribution by LaVerkin Springs (Cross 1978).

Occurrence of the woundfin in only one

TABLE 1. Phylogenetic listing of the fish fauna of the Virgin River and their general distribution. M = mainstream, T = tributary, H = headwater, N = native species.

Family	Common name	Scientific name	Distribution
Salmonidae	Cutthroat trout	*Salmo clarki*	H
	Rainbow trout	*Salmo gairdneri*	H
	Brook trout	*Salvelinus fontinalis*	H
Cyprinidae	Carp	*Cyprinus carpio*	M
	ⁿSpeckled dace	*Rhinichthys osculus*	MT
	ⁿVirgin River roundtail chub	*Gila robusta seminuda*	M
	Redside shiner	*Richardsonius balteatus hydrophlox*	T
	Red shiner	*Notropis lutrensis*	M
	ⁿVirgin River spinedace	*Lepidomeda mollispinis mollispinis*	MT
	ⁿWoundfin	*Plagopterus argentissimus*	MT
Catostomidae	ⁿFlannelmouth sucker	*Catostomus latipinnis*	MT
	ⁿDesert sucker	*Catostomus clarki*	MT
Ictaluridae	Black bullhead	*Ictalurus melas*	M
Poeciliidae	Mosquitofish	*Gambusia affinis*	M
Centrarchidae	Largemouth black bass	*Micropterus salmoides*	M
	Green sunfish	*Lepomis cyanellus*	M
	Bluegill sunfish	*Lepomis macrochirus*	M

tributary is probably related to a combination of physical and chemical factors unique among mainstream tributaries to LaVerkin Creek. The creek originates as saline springs (conductivity approximately 1,200 μmhos at 25 C), has a sand substrate, and is highly turbid. LaVerkin Creek is thus physically and chemically more similar to the mainstream than to the other tributaries. Ash Creek, which enters the Virgin River within 30 m of LaVerkin Creek, is fed by upstream runoff (conductivity about 200 μmhos at 25 C) and is generally cooler and less turbid than LaVerkin Creek. No woundfin were collected in Ash Creek during the study.

Reproduction.— The stimuli that initiate the reproductive cycle of the woundfin are not known. Spawning may be initiated by low, clear water; juvenile woundfin first appear coincident with the period of lowest river discharge. Avoidance of high spring discharges and turbidities would be advantageous because eggs spawned at that time would likely be carried away by the current or buried in silt (there is almost no submergent or emergent vegetation in the mainstream to which eggs could be affixed).

During the summer the Virgin River was often dry through the Arizona Narrows (Fig. 1). Springs emerging above Littlefield accounted for the entire river flow downstream. Two distinct sizes of young-of-the-year woundfin were present in the shallow springs during late summer: a mode about 10 mm and another about 25 mm. Apparently adult woundfin had moved into the spring area to spawn, probably in response to the low, clear water.

Lockhart (unpubl. ms.) noted that young-of-the-year woundfin exhibited growth through October. October to December appeared to be the period of highest mortality for all woundfin, coinciding with minimum water temperatures and reduced food availability.

Food Habits.— From the small sample of fish examined, woundfin appear to be omnivorous. The temporal variability of the Virgin River would place a premium on generalized or opportunistic feeding habits. The relative shortness of the gut (intestine length/standard length [Odum 1970] is slightly less than unity) would seem to preclude a predominantly algal-detrital diet. It may be that bacteria, protozoans, and microalgae adsorbed to algae and detrital particles supply the nutrients or aid in the breakdown of plant material as in the mullet, *Mugil cephalus* (Odum 1968, 1970).

Changes in Abundance.— Collections and fieldnotes examined at Brigham Young University, the University of Michigan, the University of Nevada, Las Vegas, and the U.S. National Museum indicate that woundfin abundance in the mainstream Virgin River upstream from Mesquite Nevada, has not appreciably changed since at least the 1930s (few earlier records exist). Woundfin populations downstream from Mesquite have, however, declined. The extirpation of the woundfin from the Salt and Gila rivers in Arizona was attributed to drought, agricultural operations, water storage and diversion, and the introduction of exotic species (Miller and Hubbs 1960, Minckley and Deacon 1968). These factors operate, to a greater or lesser extent, within the Virgin River basin.

Seasonal drying of extensive reaches of the mainstream has reduced the habitable range of the woundfin. Drying of the river during low discharge periods undoubtedly occurred naturally, although probably infrequently, before irrigation became widely used. At present the agricultural demand for water regularly results in dry reaches of river downstream from Hurricane, Utah, through the Arizona Narrows and downstream from Mesquite, Nevada, to Lake Mead during the summer. Reduction of available habitat was thought to be the primary factor accounting for the decline of Virgin River roundtail chub populations (Cross 1978).

Introduced species have also contributed to the decline of woundfin populations in the lower river via predation and, presumably, competition. Predation on the native species by exotics was facilitated by the creation of Lake Mead and subsequent introductions of fish into the lake. Potential predators on the woundfin, including largemouth black bass, bluegill and green sunfish, black bullheads, and mosquitofish, are present in the lower river mainly as seasonal (summer and fall) emigrants from Lake Mead.[2] Examination of the stomachs of two largemouth black bass (118 and 167 mm SL) from August collections revealed one unidentifiable fish in the first and a 50 mm woundfin in the second.

Competition is more difficult to prove and only circumstantial evidence exists for competition between the red shiner, a small, omnivorous cyprinid, and the woundfin. Downstream from Mesquite, woundfin abundance decreased while red shiner abundance increased. At Station 1 (Fig. 1) the red shiner regularly comprised 90 percent or more of the fauna; at Station 2 it averaged about 40 percent of the fauna; and at Station 3 it was captured infrequently. This situation could have resulted from a deterioration of the habitat beyond the tolerance range of the woundfin, but not beyond that of the red shiner. The red shiner is capable of withstanding intermittence, high temperatures, and high turbidities (Koster 1957, Cross 1967). Within its native range (midwestern United States) the red shiner rarely becomes abundant in clear streams with constant discharge and large populations of other cyprinids, but it increases rapidly in abundance when drought decreases streamflow and alters the composition of the fauna (Cross 1967).

Alternatively, the decline of the woundfin may have been a result of competition with the red shiner. The woundfin is also particularly well adapted to the extreme fluctuations in discharge, suspended sediment, and temperature. It commonly occurred in habitat unsuitable for the other native species due to high temperatures (the LD_{50} for woundfin acclimated at 21.5 C was 34.5 C (Lockhart, unpubl. mans.), minimal river flow, or organic pollution. The scarcity of woundfin in the lower river is not likely attributable to the poor quality of the habitat—comparable conditions occur upstream from the Arizona Narrows where woundfin are frequently the only species collected. What is more probable is that as a result of the presence of the red shiner, woundfin abundance has declined. A similar correlation between an increase in abundance of the red shiner and the disappearance of the native cyprinids *Meda fulgida* and *Tiaroga cobitis* was observed in the Gila River basin in Arizona (Minckley and Deacon 1968, Minckley 1973).

The woundfin presently persists over at least half of its original range within the Virgin River basin. The precarious nature of its existence has prompted its inclusion in the U.S. Bureau of Sport Fisheries and Wildlife (1973) listing of endangered species. The continued existence of the woundfin in the Virgin River basin is directly linked to the amount of further physical, chemical, and biological alterations of the mainstream habitat.

ACKNOWLEDGMENTS

The following participated in various aspects of the fieldwork, and their assistance is gratefully acknowledged: H. A. Berry, P. J. Calos, C. D. Deacon, J. E. Deacon, G. C. Faber, J. Lockhart, and L. Loetterle. Access to museum collections was made possible by: Dr. R. R. Miller (University of Michigan Museum of Zoology); Dr. W. W. Tanner (Brigham Young University); Dr. E. A. Lachner (U.S. National Museum); and Dr. W. L. Minckley (Arizona State University). The figure was prepared by Jan Shines. A special acknowledgment goes to J. E. Deacon, my major professor, for his ideas and encouragement during the study.

LITERATURE CITED

COOK, E. F. 1960. Geologic atlas of Utah: Washington County. Utah Geol. Mineral. Surv., Bull. 70.

CROSS, F. B. 1967. Handbook of fishes of Kansas. Misc. Publ. Mus. Nat. Hist. Univ. Kans. 45:1–357.

CROSS, J. N. 1978. Status and ecology of the Virgin River roundtail chub *Gila robusta seminuda* (Osteichthyes: Cyprinidae). Southwest. Nat. 23:519–528.

DEACON, J. E., AND W. L. MINCKLEY. A review of in-

---

[2] Few introduced fish persist in the river through the spring highwater period. Consequently, annual flooding has limited the upstream penetration of introduced species; the farthest upstream penetration recorded during the study was 100 km. The majority of the introduced fishes were collected within 70 km of Lake Mead.

formation on the woundfin, *Plagopterus argentissimus* Cope. University of Nevada, Las Vegas. Unpublished manuscript.

HUBBS, C. L. 1954. Establishment of a forage fish, the red shiner (*Notropis lutrensis*), in the lower Colorado River system. Calif. Fish Game 40:287-294.

KOSTER, W. J. 1957. Guide to the fishes of New Mexico. Univ. New Mexico Press, Albuquerque.

LOCKHART, J. Research conducted on *Plagopterus argentissimus*. University of Nevada, Las Vegs. Unpublished manuscript.

MCKEE, E. D., R. F. WILSON, W. J. BREED, AND C. S. BREED. 1967. Evolution of the Colorado River in Arizona. Mus. North. Ariz., Flagstaff, Bull. 44.

MILLER, R. R., AND C. L. HUBBS. 1960. The spiny-rayed cyprinid fishes (Plagopterini) of the Colorado River system. Misc. Publ. Mus. Zool. Univ. Mich. 115:1-39.

MINCKLEY, W. L. 1973. Fishes of Arizona. Arizona Game Fish Dept., Tucson.

MINCKLEY, W. L., AND J. E. DEACON. 1968. Southwestern fishes and the enigma of "Endangered species." Science 159:1424-1432.

ODUM, W. E. 1968. The ecological significance of fine particle selection by the striped mullet *Mugil cephalus*. Limnol. Oceanogr. 13:92-97.

______. 1970. Utilization of the direct grazing and plant detritus food chains by the striped mullet *Mugil cephalus*, p. 222-240. *In*: J. H. Steele (ed.), Marine food chains. Univ. Calif. Press, Berkeley.

U.S. BUREAU OF SPORT FISHERIES AND WILDLIFE. 1973. Threatened wildlife of the United States. But. Sport Fish. Wildl. Res. Publ. 114.

AN ECOLOGICAL AND TAXONOMIC INVESTIGATION OF *PEROMYSCUS MANICULATUS SERRATUS* IN IDAHO

Thomas L. Thurow[1]

Abstract.— Twenty-two sites in central Idaho were sampled to determine the geographic range of *Peromyscus maniculatus serratus.* Isolating mechanisms which exist between the *P. maniculatus* subspecies of region require further investigation.

While trapping in central Idaho during 1936, William B. Davis recorded a race of deermouse consistently exhibiting characteristics unlike those of other subspecies found in that region. Although this new population was located geographically between the range of *Peromyscus maniculatus artemisiae* to the east, west, and north and *P. m. sonoriensis* to the south, it did not appear to be the result of intergradation between these latter populations. Consequently, Davis (1939) described a new subspecies which he named *P. m. serratus.* Davis sampled primarily near the Sawtooth and Challis regions, leaving largely unknown the extent of the range of the subspecies. Boundaries were hypothesized to extend north to the Salmon River. Little indepth study of *P. m. serratus* was conducted after the conclusion of this initial description.

In 1975, it was noted that the subspecies of deermouse found at the University of Idaho Wilderness Research center located on Big Creek in the Idaho Primitive Area appeared to be *P. m. artemisiae* (Elliott 1976). Because Big Creek is approximately 30 miles south of the Salmon River, this finding hinted that the range of *P. m. serratus* might be significantly reduced from the range suggested by Davis and illustrated by Hall and Kelson (1959). The present investigation was undertaken to determine the range of *P. m. serratus* and to identify, if possible, the factors of selection that preserve the integrity of the gene pools of the three subspecies.

Twenty-two sites in the vicinity of the expected range of *P. m. serratus,* including the approximate locations of the four trapping sites used by Davis in 1936, were sampled (Fig. 1). A tail to head and body mean ratio of 92 percent combined with prominent white subauricular patches were the best external field marks that could be used to identify adult *P. m. serratus.* The subspecies *P. m. artemisiae* has a tail to head and body mean ratio of 80 percent and faint or absent subauricular patches, while *P. m. sonoriensis* has a comparatively small tail to head and body mean ratio of 73 percent and possesses small white subauricular patches.

Average body and cranial measurements of the three *P. maniculatus* subspecies found in Idaho are shown in Table 1. It shows that *P. m. serratus* exhibits a longer total length, longer tail and larger hind feet and ears than either *P. m. artemisiae* or *P. m. sonoriensis.* The skull of *P. m. serratus* averages larger, with the cranial portion appearing to be slightly more inflated when compared to skull measurements of *P. m. artemisiae* and *P. m. sonoriensis* from neighboring sample areas and those given by Osgood (1909). Bacular measurements of adult *P. m. serratus* averaged longer than either *P. m. artemisiae* or *P. m. sonoriensis*

Secondary intergradation (Mayr et al. 1953) appears to have occurred at Station 22 between *P. m. serratus* and *P. m. sonoriensis.* as an entire spectrum of traits of both subspecies were found. At Stations 10 and 16 the specimens indicate *P. m. artemisiae.* The other 18 trapping stations exhibit a uniform set of traits characteristic of

---

[1]Department of Zoology, Brigham Young University, Provo, Utah 84602.

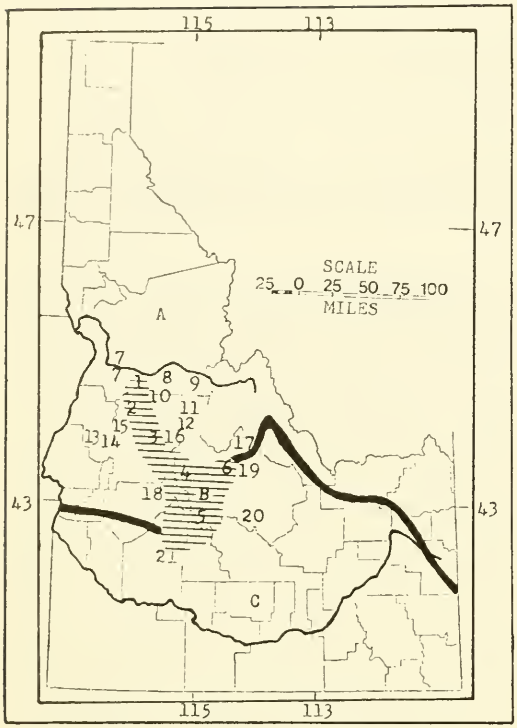


Fig. 1. Distribution of deer mouse subspecies in Idaho: (a) *Peromyscus maniculatus artemisiae,* (b) *Peromyscus maniculatus serratus,* (c) *Peromyscus maniculatus sonoriensis.*

one subspecies, as is illustrated by tail to head and body ratios of the data collected in this study (Table 2). A comparison of measurements of *P. m. serratus* from my study with the expected tail to head and body mean ratio of 92 percent reveal the difference to be nonsignificant ($X^2=2.36$, 3df., $.8>P>.5$). Comparisons of difference between *P. m. artemisiae* measurements from my study to the expected ratio mean of 80 percent ($X^2=2.75$, 5df., $.8>P>.5$) and my *P. m. sonoriensis* data with its expected ratio mean of 73 percent ($X^2=3.80$, 1df., $.1>P>.05$) also proved to be nonsignificant.

With the range of *P. m. serratus* thus established a number of pertinent questions arise. Foremost of these is what parameters are serving to maintain the subspecies *P. m. serratus*? Cover and overstory vegetation were measured and recorded using the line intercept method (Smith 1973) at each trapping site. Where *P. m. serratus* and *P. m. sonoriensis* ranges meet an apparent boundary is provided because *P. m. sonoriensis* is found primarily in sagebrush and bunchgrass associations and *P. m. serratus* remains on the forested hillsides and creekbottoms.

No gross vegetational factors were found to deliniate a range separation where *P. m.*

Table 1. Body and cranial measurements of *P. maniculatus* specimens. Assignment of specimens to subspecies was based primarily on tail to head and body ratios as well as body markings.

Measurements in millimeters	*P. m. artemisiae* $\bar{X}$	C.L.[2]	*P. m. serratus* $\bar{X}$	C.L.	*P. m. sonoriensis* $\bar{X}$	C.L.	Intergrades[1] $\bar{X}$	C.L.
Total length	170.5	(167.8-173.2)	183.4	(181.0-185.8)	170.1	(166.2-174.0)	167.8	(164.2-171.2)
Tail length	76.1	(74.3-77.9)	87.4	(86.0-88.8)	72.8	(70.9-74.7)	74.3	(72.3-76.3)
Hindfoot length	21.0	(20.7-21.3)	23.4	(23.2-23.6)	20.6	(20.3-20.9)	21.6	(21.1-22.1)
Ear length	18.9	(18.4-19.4)	22.8	(22.5-23.1)	17.8	(17.2-18.4)	20.5	(19.9-22.1)
Ratio, tail:head and body	80.3	(78.6-83.0)	91.0	(89.5-92.5)	74.9	(73.3-76.5)	79.5	(76.7-82.3)
Zygomatic breadth	13.1	(12.9-13.3)	13.4	(13.2-13.6)	13.4	(13.2-13.6)	13.3	(13.1-13.5)
Occipital-nasal length	26.4	(26.1-26.7)	27.0	(26.7-27.3)	26.6	(26.2-27.0)	26.7	(26.3-27.1)
Cranium breadth	11.2	(11.0-11.4)	10.9	(10.7-11.1)	11.0	(10.9-11.1)	11.0	(10.9-11.1)
Maxillary tooth row length	3.9	(3.7-4.1)	3.9	(3.8-4.0)	3.8	(3.7-3.9)	3.9	(3.8-4.0)
Incisor-maxillary diastema	7.4	(7.2-7.6)	7.1	(7.0-7.2)	6.9	(6.7-7.1)	7.2	(7.0-7.4)
Palate length	4.2	(4.0-4.4)	4.0	(3.9-4.1)	4.3	(4.2-4.4)	4.3	(4.1-4.5)
Incisive foramen length	5.9	(5.8-6.0)	5.9	(5.8-6.0)	5.5	(5.3-5.7)	5.8	(5.6-6.0)
Post-palital length	9.7	(9.5-9.9)	9.6	(9.4-9.8)	9.2	(9.0-9.4)	9.4	(9.2-9.6)
Interorbital constriction	4.0	(3.9-4.1)	4.2	(4.1-4.3)	3.9	(3.8-4.0)	4.1	(4.0-4.2)
Nasal length	11.5	(11.3-11.7)	11.0	(10.8-11.2)	10.8	(10.6-11.0)	11.0	(10.8-11.2)
Baculum length	8.7	(8.5-8.7)	10.9	(10.6-11.2)	8.4	(7.8-9.0)	9.0	(8.0-10.0)

[1] Assumed intergrades P. m. serratus × P. m. sonoriensis taken at trapping Site 22 (Fig. 1).

[2] Confidence limits at the 95 percent confidence level.

artemisiae and *P. m. serratus* ranges meet. Further investigation of such factors as geographic barriers, climatic patterns, and soil types offered no solution. One environmental factor was discovered to have a high correlation with the range of *P. m. serratus*, that being an isobar illustrating the average date (30 June) of the last killing frost (Yearbook of Agriculture 1941).

An apparent discrepancy between this frost date isobar and the range of *P. m. serratus* appears in the eastern portion of the range approaching Challis, Idaho. However, since no weather data of this nature are available from that area the frost line could in fact include this drainage in question. Another one of many possibilities is that *P. m. serratus* is a glacial remnant, having survived that geologic time period through isolation in the rugged terrain of the Sawtooth Mountains. Physical, physiological, and behavioral barriers to breeding between *P. m. artemisiae* and *P. m. serratus* should be investigated. Until the isolating mechanisms between these gene pools is identified, the subspecific ranking of *P. m. serratus* will remain in doubt. Further research, investigating these and other aspects, would certainly be a warranted step to gaining a fuller knowledge of this restricted member of North American fauna.

I thank Drs. Jerran T. Flinders and Ernest D. Ables for their appreciated guidance throughout various stages of this project and

TABLE 2. Average ratios (expressed as percent) of tail to head and body measurements of all adult *P. maniculatus* specimens from 22 trapping sites in central Idaho.

Site number	Sample area	Sample size	Mean Ratio (percent) of tail to head and body
	Peromyscus maniculatus serratus		
1	30 mi. E. of Burgdorf	5	89.6
2	20 mi. E. of McCall	5	94.0
3	9 mi. E. of Warm Lake	12	93.5
4	5 mi. W. of Cape Horn	8	88.2
5	14 mi. W. of Challis	11	90.5
6	Alturus Lake	5	89.0
	Total	46	91.0
	Peromyscus maniculatus artemisiae		
7	10 mi. E. of Riggins	10	82.3
8	Chamberlain airstrip	11	80.0
9	Cold Meadows airstrip	10	83.9
10	Big Creek airstrip	3	84.6
11	Taylor Ranch-Cliff Creek	21	78.5
12	Taylor Ranch-Rush Creek	19	77.5
13	Flying "B" airstrip	1	79.1
14	18 mi. W. of Donnelly	15	79.5
15	5 mi. W. of Donnelly	10	81.8
16	8 mi. N.E. of Donnelly	4	84.7
17	Indian Creek airstrip	8	83.1
18	Alder Creek—25 mi. N. of Challis	12	79.2
19	5 mi. W. of Lowman	15	80.1
	Total	139	80.3
	Peromyscus maniculatus sonoriensis		
20	9 mi. W. of Challis	8	73.8
21	18 mi. N.E. of Sun Valley	14	75.5
	Total	22	74.9
	Secondary intergradation of *P. m. serratus* with *P. m. sonoriensis*		
22	3 mi. N. of Pine	19	79.5

for critically reading the manuscript. I also wish to thank Drs. Donald Johnson and Steven Peterson for their helpful comments and Kenneth Sowles for his continual project aid and expert flying into various backcountry airstrips. This work was supported through an honorarium from the Wilderness Research Center of the University of Idaho.

LITERATURE CITED

DAVIS, W. B. 1939. The recent mammals of Idaho. pp. 288–293. Caldwell, Idaho: Caxton Printers, Inc.

ELLIOTT, C. L. 1976. The effect of altitude upon various physical and reproductive factors in a population of *Peromyscus maniculatus*. Undergraduate research report, Student Wilderness Study Program. 13 pp. Unpublished manuscript.

HALL, E. R., AND K. R. KELSON. 1959. The mammals of North America II: 612–624. New York: Ronald Press Co.

MAYR, E., E. G. LINSLEY, AND R. L. USINGER. 1953. Methods and principles of systematic zoology. New York: McGraw-Hill Book Co. 328pp.

OSGOOD, W. H. 1909. Revision of the mice of the American genus *Peromyscus*. N. Amer. Fauna 28:1–285.

SMITH, R. L. 1974. Ecology and field biology. pp. 695–696. New York: Harper and Row Pub.

U.S. DEPARTMENT OF AGRICULTURE. 1941. Yearbook of agriculture: climate and man. pp. 829–840. Washington D.C.: United States Government Printing Office.

THE EYE FLUKE DISEASE (DIPLOSTOMATOSIS) IN FISHES FROM UTAH

Richard A. Heckmann[1] and James R. Palmieri[1]

Abstract.— During 1976 and 1977, 798 fish representing 11 species from eight collection sites in Utah were examined for metacercariae of *Diplostomum spathaceum*, which causes the fish eye fluke disease, diplostomatosis. Eight species were infected. The infection rate ranged from 7 percent of 46 *Salmo gairdneri* from Soldiers Creek Reservoir to 100 percent in 7 species of fish from four collection sites. Summary charts for four years of data are given for collection sites, piscine hosts in Utah, and fish hosts for Strawberry Reservoir, Utah.

During the past four years we have been studying the incidence, life history, morphology, host-parasite relationships, and control of *Diplostomum spathaceum* in Utah fishes. Palmieri et al. (1977) reported on the life history and habitat analysis of the eye fluke. The incidence of infection for 1974 and 1975 was reported in a previous publication (Evans et al. 1976).

Diplostomum spathaceum (Rudolfi 1819), or the fish eye fluke which causes the disease diplostomatosis, was reported in Strawberry Reservoir, Utah, by the Division of Wildlife Resources in 1973. Fish are the most common second intermediate hosts; however, infections in amphibians, reptiles, and mammals have also been reported (Ferguson 1943). Once the cercariae have penetrated the second intermediate host, they lose their forked tails and migrate to the lens tissue, where the metacercariae develop in 50–60 days (Erasmus 1958). Diplostomatosis causes cataracts of the lens tissue, due to the presence of the metacercarial stage of this parasite. Visual acuity for infected fish can be slightly hampered or lost, depending on the number of worms present. In addition to visual loss, fish show retarded growth and a change in food habits. Increase in the incidence of the disease in the state has generated public and academic concern.

The purpose of this paper is to report on the last two years of survey data (1976–1977) for the prevalence of the eye fluke in fish, indicate new hosts for Utah and sites of infection, and summarize four years of data for Strawberry Reservoir, Utah.

Materials and Methods

A survey of piscine hosts was accomplished with the cooperation of the Utah Division of Wildlife Resources. Regional fisheries biologists provided heads of fish sampled during routine and annual investigations of fish populations throughout the state. Arrangements were made to obtain the samples following the inventories accomplished by the state fisheries biologists. Fish were collected by gill net, seine, and hook and line, then placed in ice chests until the senior author obtained the samples for study at Brigham Young University. The species was determined and recorded.

In the laboratory, fish were examined for metacercariae of *D. spathaceum*. Each individual eye was extracted and carefully examined, records of fish and lens condition determined, and individual numbers of worms found infecting the right and left eye recorded.

Results

A total of 798 fish were examined from eight collection sites in Utah during 1976 and 1977 (Table 1). Of the 11 species of fish, 8 were infected with the metacercariae of *D. spathaceum* (Table 1).

---

[1] Department of Zoology, Brigham Young University, Provo, Utah 84602.

There are 13 known piscine hosts for the eye fluke in Utah (Table 2), which have been found at 14 sites (Table 3). From pre-

Table 1. Location, fish host, and parasite infection data of *Diplostomum spathaceum* for Utah (1976 and 1977).

Collection date	Reservoir collection locality	Hosts collected	Number of fish	Percent infection of fish	Average number metacercariae/host (Range in parenthesis)
27-VI-1976	East Canyon	*Salmo gairdneri*	19	95	7.4 (0–30)
		Salmo clarki	3	100	2.0 (1–3)
		Richardsonius balteatus	6	100	9.7 (1–16)
		Catostomus ardens	7	100	66.7 (7–105)
27-IV-1976	Echo	*Salmo gairdneri*	8	13	1 (0–1)
		Prosopium williamsoni	6	0	0
		Cyprinus carpio	1	0	0
		Catostomus ardens	2	0	0
		Catostomus platyrhynchus	4	0	0
27-IV-1976	Rockport	*Salmo trutta*	3	0	0
		Salmo gairdneri	14	14	1.5 (0–2)
		Catostomus platyrhynchus	1	0	0
		Gila atraria	12	25	1 (0–1)
30-IV-1976	Lost Creek	*Salmo clarki*	13	0	0
		Salmo gairdneri	6	0	0
		Catostomus ardens	14	72	18.0 (0–131)
		Gila atraria	27	48	3.1 (0–6)
14-V-1976	Hyrum Dam	*Salmo gairdneri*	55	100	16.4 (3–42)
		Salmo trutta	5	80	4.3 (0–7)
		Cyprinus carpio	8	50	6.2 (0–10)
13-V-1976	Pineview	*Ictalurus melas*	9	78	2.6 (0–5)
		Salmo gairdneri	16	86	2.7 (0–7)
		Cyprinus carpio	2	50	4.0 (0–4)
		Gila atraria	12	100	3.1 (1–7)
		Lepomis macrochirus	12	100	3.6 (1–10)
19-V-1976	Soldiers Creek	*Salmo gairdneri*	46	7	1.3 (0–2)
		Salvelinus fontinalis	1	0	0
20-V-1976	Strawberry	*Salmo clarki*	19	84	3.0 (0–11)
		Salmo gairdneri	82	100	30.1 (1–200+)
		Catostomus platyrhynchus	15	100	151.5 (58–200+)
		Richardsonius balteatus	18	100	6.3 (1–23)
28-V-1976	Strawberry	*Richardsonius balteatus*	25	100	5.9 (1–72)
28-XI-1976	Strawberry	*Salmo clarki*	30	80	2.6 (0–18)
		Gila atraria	34	97	3.6 (0–10)
		Salmo gairdneri	52	100	85.4 (3–200+)
		Richardsonius balteatus	9	89	2.8 (0–6)
3-VI-1977	Strawberry	*Salmo gairdneri*	27	100	34.2 (1–200+)
		Salmo clarki	15	93	3.4 (0–12)
		Richardsonius balteatus	6	100	4.1 (1–15)
		Gila atraria	20	90	3.6 (0–9)
		Catostomus platyrhynchus	10	100	189.1 (62–200+)
15-VI-1977	Strawberry	*Salmo gairdneri*	31	100	35.2 (1–200+)
		Salmo clarki	14	86	2.8 (0–7)
		Gila atraria	16	100	3.4 (1–14)
		Catostomus platyrhynchus	10	100	176.2 (58–200+)
		Richardsonius balteatus	10	90	3.5 (0–9)
		Catostomus ardens	12	100	12.3 (3–17)
		Salvelinus fontinalis	1	100	168 (168)
		Rhinichthyes cataractae	10	0	0

vious published data (Palmieri et al. 1976b, 1977) we have added 3 additional hosts and included 4 more sites for diplostomatosis in Utah. The rate of infection varied from 7 percent for a *Salmo gairdneri* from Soldiers Creek Reservoir to 100 percent found in seven species of fish (*Salmo gairdneri, Richardsonius balteatus, Catostomus ardens, Gila atraria, Lepomis macrochirus, Catostomus platyrhynchus, Salvelinus fontinalis*) from 4 of the 8 collection sites (Table 1).

To date, a total of 1637 fish, including 22 species from 21 collection sites throughout Utah, have been checked for diplostomatosis. Although the number of metacercariae in the right and left lenses of individual hosts seldom was identical, no significant lens preference was noted. Examination of data related to host-sex susceptibility to infection by metacercariae of *D. spathaceum* revealed no significant correlation.

The rate of infection of *D. spathaceum* across Utah is high, as exemplified by samples from Strawberry Reservoir (Table 4). For this body of water, three species of fish, *Salmo gairdneri, Salvelinus fontinalis,* and *Catostomus platyrhynchus,* have large numbers of metacercariae which probably impair vision.

Discussion

Samples of fish from eight collection sites in Utah were examined for *Diplostomum spathaceum* metacercariae. These data substantiated previous results (Palmieri et al. 1977) that the rate of infection across Utah is high and widespread. Three additional piscine hosts and four reservoirs are included on the lists for intermediate hosts and habitats respectively. There are sites in Utah where the fluke has not been found. The reason for this is indicated by the lack of the needed shoreline and bottom vegetation, so important for the development, growth, and reproduction of snails. The lack of vegetation, snail, and gull hosts, as well as the presence of low water temperatures, probably accounts for the low infection rate in high alpine lakes. The lack of shoreline vegetation is another reason for the absence of the disease in reservoirs and lakes at lower elevations.

There has been an increase in the incidence of metacercariae for fish in Strawberry Reservoir (Table 4). *Salmo gairdneri* has gone through an increase in prevalence and numbers during the last four years. The last samples of this piscine host suggest a stabilization in number of worms per eye (range 1 to 200+). The Utah chub, *Gila atraria*, has become prominent in recent gill net samples from Strawberry Reservoir. All

Table 2. Summary of fish hosts positive for metacercariae of *Diplostomum spathaceum* in Utah.

Fish host	Number examined	Range of infection with metacercariae (percent)
Catostomus ardens	42	72–100
Catostomus discobolus	26	0–5.8
Catostomus platyrhynchus	117	60.5–100
Cyprinus carpio	8	0–50
Gila atraria	210	0–100
Ictalurus melas	9	0–78
Lepomis macrochirus	12	0–100
Micropterus salmoides	61	0–49
Salmo clarki	179	0–100
Salmo gairdneri	792	0–100
Salmo trutta	21	0–100
Salvelinus fontinalis	14	0–100
Richardsonius balteatus	91	0–100

Table 3. Collecting sites for intermediate hosts (fish) of *Diplostomum spathaceum* in Utah.

Collection site	County
Ash and LaVerkin creeks	Washington
Deer Creek Reservoir	Wasatch
Echo Reservoir*	Morgan
East Canyon Reservoir*	Davis
Fish Lake*	Sevier
Flaming Gorge Reservoir*	Daggett
Hyrum Reservoir*	Cache
Kolob Reservoir	Washington
Lake Powell	Kane and San Juan
Lost Creek Reservoir*	Summit
Mantua Reservoir*	Box Elder
Mirror and Lost lakes	Summit
Nine-Mile Reservoir*	Sanpete
Otter Creek Reservoir*	Piute
Palisade Lake*	Sanpete
Pineview Reservoir*	Weber
Rockport Reservoir*	Summit
Scofield Reservoir	Carbon
Soldiers Creek Reservoir*	Wasatch
Strawberry Reservoir*	Wasatch
Utah Lake	Utah

*Contain infected fish

the chub from the last sample were infected with limited numbers (1 to 14 per host) of metacercariae. There has been no significant change in the infection rate for *Salmo clarki, Catostomus platyrhynchus,* and *Salvelinus fontinalis* during the four-year sampling period for Strawberry Reservoir (Table 4).

The pathological effects of *Diplostomum spathaceum* upon the fish host are many. Examination of those fish blinded with cataract and containing a heavy burden of larval metacercariae revealed stunted growth (length, girth, and weight), abnormal feeding behavior (lack of response to visual stimuli), and decreased vital acuity (Palmieri et al. 1977). Ashton et al. (1969) reported that larvae migrate to the eye via vascular-venous channels and showed that the lens, vitreous, or cortex of the eye may be pro-

Table 4. Fish sampled from Strawberry Reservoir, four years.

Host species	Date of sample	Number of fish	Percent infection	Average number of metacercariae (Range in parenthesis)
Salmo clarki	20-IV-74	19	48	3.4 (0–5)
(Cutthroat trout)	6-IX-74	9	56	4.2 (0–6)
	5-VI-75	75	88	7.3 (0–23)
	30-X-75	10	90	2.1 (0.5)
	20-V-76	19	84	3.0 ((0–11)
	28-XI-76	30	80	2.6 (0–18)
	3-VI-77	15	93	3.4 (0–12)
	15-VI-77	14	86	2.8 (0–7)
Salmo gairdneri	20-VI-74	4	75	8.6 (0–20)
(Rainbow trout)	9-VIII-74	49	98	13.4 (0–22)
	6-XI-74	71	98	11.9 (0–27)
	5-VI-75	35	97	40.0 (0–200+)
	8-VII-75	2	100	33.5 (1–200+)
	10-VII-75	2	100	2.0 (1–13)
	30-X-75	53	93	14.5 (0–54)
	20-V-76	82	100	30.1 (1–200+)
	18-XI-76	52	100	85.4 (1–200+)
	3-VI-77	27	100	34.2 (1–200+)
	15-VI-77	31	100	35.2 (1–200+)
Salvelinus fontinalis	30-X-75	3	100	32.6 (5–31)
(Brook trout)	5-VI-75	4	100	140.9 (25–200+)
	15-VI-77	1	100	168 (168)
Catostomus platyrhynchus	20-VI-74	8	100	102.9 (35–200+)
(Mountain sucker)	6-XI-74	15	100	81.1 (6–200+)
	5-VI-75	21	100	112.0 (25–200+)
	30-X-75	9	100	159.6 (39–200+)
	20-V-76	15	100	151.5 (25–200+)
	3-VI-77	10	100	189.1 (62–200+)
	15-VI-77	10	100	176.2 (58–200+)
Catostomus ardens	5-VI-75	11	100	8.8 (2–14)
(Utah sucker)	15-VI-77	12	100	12.3 (3–17)
Richardsonius balteatus	5-VI-75	5	80	30.6 (0–57)
(Redside shiner)	30-X-75	22	95	7.2 (0–16)
	20-V-76	18	100	6.3 (1–23)
	28-V-76	25	100	5.9 (1–22)
	28-XI-76	9	89	2.8 (0–6)
	3-VI-77	6	100	4.1 (1–15)
	15-VI-77	10	90	3.5 (0–9)
Gila atraria	28-XI-76	34	80	2.6 (0–18)
(Utah chub)	3-VI-77	20	90	3.6 (0–9)
	15-VI-77	16	100	3.4 (1–14)
Rhinichthyes cataractae	15-VI-77	10	0	0 0

liferated with metacercariae. In older fish, chronic infections produced subacuate inflammatory reactions in the vitreous involving heterophils and eosinophils, and macrophages with ingested lens material occurred.

There are many possible techniques to investigate concerning the control of diplostomatosis. One that shows promise is biological control by the use of a protozoan hyperparasite, *Nosema strigeoidea* (Protozoa: Microsporida). Hussey reported in 1971 the above species of microsporidia to be host specific for hyperparasitizing sporocysts of *Diplostomum spathaceum*. Palmieri et al. (1976a, 1976c) substantiated Hussey's work for the eye fluke in Utah.

Spores of *N. strigeoideae* were introduced to laboratory-reared snails (*Lymanaea auricularia*) containing sporocysts of *D. spathaceum*. The spores selectively attack the mother and daughter sporocysts as well as the developing cercarial embryos and retard, disfigure, and disrupt normal cercarial development. The microsporidian spores have no outward pathological effect upon the molluscan host. Further work is needed to determine the potential use of this control method for diplostomatosis and investigations pertaining to resistant fish hosts, stimulus for cercarial migration, immune responses, and the potential human health hazard.

ACKNOWLEDGMENTS

The authors wish to thank the Utah Division of Wildlife Resources for specimen collection and the National Science Foundation (Grant EPP 75-04396) for financial support.

LITERATURE CITED

ASHTON, N., N. BROWN, AND D. EASTY. 1969. Trematode cataract in freshwater fish. J. Small Anim. Pract. 10:471–478.

ERASMUS, D. A. 1958. Studies on the morphology, biology, and development of a strigeid cercariae (cercaria X Baylis). Parasitology 48:312–335.

EVANS, R. S., R. A. HECKMANN, AND J. R. PALMIERI. 1976. Diplostomatosis in Utah. Proc. Utah Acad. Sci. 53(1):20–25.

FERGUSON, M. 1943. Development of eye flukes of fishes in the lenses of frogs, turtles, birds and mammals. J. Parasitol. 29:136–142.

HUSSEY, K. L. 1971. A microsporidean hyperparasite of strigeoid trematodes *Nosema strigeoidea* sp. n. J. Parasitol. 18(4):676–679.

PALMIERI, J. R., R. A. HECKMANN, AND R. S. EVANS. 1977. Life history and habitat analysis of the eye fluke *Diplostomum spathaceum* (Trematoda: Diplostomatidae) in Utah. J. Parasitol. 63:427–429.

______. 1976b. Life cycle and incidence of *Diplostomum spathaceum* Rudolphi (1819) (Trematoda: Diplostomatidae) in Utah. Great Basin Nat. 36(1):86–96.

PALMIERI, J. R. AND R. A. HECKMANN. 1976a. Potential biological control of diplostomatosis (*Diplostomum spathaceum*) in fishes by hyperparasitism. Proc. Utah Acad. Sci. 53(1):17–19.

PALMIERI, J. R., R. A. HECKMANN, AND A. CALI. 1976c. Experimental biological control of the eye fluke *Diplostomum spathaceum* by a hyperparasite, *Nosema strigeoidea* (Protozoa: Microsporida). J. Parasitol. 62(2):325–326.

BITE OF WOLF SPIDER

Dorald M. Allred[1]

Abstract.— A man bitten on the finger by a wolf spider, *Lycosa* sp., experienced temporary bleeding and tingling of the finger, but no other symptoms occurred.

On September 11, 1978, a male construction worker about thirty years of age was admitted to the emergency ward of the Utah Valley Hospital, Provo, Utah, for treatment of a spider bite. He had grasped the underside of a broken concrete block and felt a pain like a thorn prick on the back of his middle finger. A wolf spider was found on the underside of the block. The worker had apparently imprisoned it by pressing one of its legs against the block.

The paired cheliceral wounds were situated transversely on the finger next to the fingernail. They bled freely for a few minutes, and the victim experienced a temporary tingling of his finger which lasted only for a few minutes. He was discharged without treatment other than application of a disinfectant. No further symptoms were experienced.

Unfortunately a co-worker struck the spider with a hammer. The remains brought in were identified as a *Lycosa* female, probably *carolinensis* based on size and color pattern of the legs and cephalothorax.

---

[1] 290 Life Science Museum, Brigham Young University, Provo, Utah 84602.

INDEX TO VOLUME 38

The genera and species described as new to science in this volume appear in bold type in this index.

A comparative analysis of the diatom flora on the snail *Ampullaria cuprina* from the Goshen Ponds, Utah, p. 211.
A new subspecies of the snake *Lichanura trivirgata* from Cedros Island, Mexico, p. 411.
Allelopathic effects of Bur Buttercup tissue on germination and growth of various grasses and forbs in vitro and in soil, p. 90.
Allred, Dorald M., article by, p. 478.
An addition to the amphibian fauna of California, p. 429.
An annotated list of the aquatic insects of southeastern Idaho, Part III. Ephemeroptera, p. 55.
An ecological and taxonomic investigation of *Peromyscus maniculatus serratus* in Idaho, p. 469.
Andersen, Ferron L. and Graham R. Bullick, article by, p. 369.
Astragalus lentiginosus var. **wahweapensis**, p. 286.
Astragalus **montii**, p. 11.
Astragalus subcinereus var. **basalticus**, p. 302.
Atwood, N. Duane, Stanley L. Welsh, and Joseph R. Murdock, article by, p. 125.
Axler, R. P., R. M. Gersberg, and L. J. Paulson, article by, p. 187.
Basidiomycetes that decay junipers in Arizona II, p. 42.
Baumann, Richard W., and Bill P. Stark, article by, p. 97.
Bite of wolf spider, p. 478.
Bright, Donald E., article by, p. 71.
Brotherson, J. D., G. Nebeker, M. Skougard, and J. Fairchild, article by, p. 19.
Brotherson, Jack D., Mark C. Whiting, and Samuel R. Rushforth, article by, p. 31.
Buchanan, Bruce A., K. T. Harper, and Neil C. Frischknecht, article by, p. 90.
Bullick, Graham R., and Ferron L. Andersen, article by, p. 369.
Campbell, W. F., and E. A. Rechel, article by, p. 456.
Conophthorus **echinatae**, p. 398.
Contributions to the biology of the woundfin, *Plagopterus argentissimus* (Pisces: Cyprinidae), an endangered species, p. 463.
Correction: *Rhamnus cathartica* L. is not *Prunus nigra* Ait. from Alberta, p. 123.
Cross, Jeffrey N., article by, p. 463.
Current status of cutthroat trout subspecies in the western Bonneville Basin, p. 193.
Differential parasitism of *Peromyscus maniculatus* and *Peromyscus truei*, by *Cuterebra* larvae, p. 51.
Distributional records for the Colorado flora, p. 208.
Duff, Donald A., and Terry J. Hickman, article by, p. 193.
Eads, Richard B., article by, p. 447.
Effect of irrigation on survival of third-stage *Haemonchus contortus* larvae (Nematoda: Trichostrongylidae), p. 369.
Endangered and threatened plants of Utah: A reevaluation, p. 1.
Engstrom, Mark D., and Eugene D. Fleharty, article by, p. 180.
Environmental interaction in summer algal communities of Utah Lake, p. 31.
Eridiphas sleveni **macrosensis**, p. 407.
Evans, Howard E., and William L. Rubink, article by, p. 59.
Fairchild, J., J. D. Brotherson, G. Nebeker, and M. Skougard, article by, p. 19.
Feddema, C., D. Wilken, W. Harmon, and H. Harrington, article by, p. 208.
Fleharty, Eugene D., and Mark D. Engstrom, article by, p. 180.
Fluctuation of a marsh habitat and the reproductive strategy of the Yellowheaded Blackbird, p. 85.
Frischknecht, Neil C., Bruce A. Buchanan, and K. T. Harper, article by, p. 90.
Gersberg, R. M., R. P. Axler, and L. J. Paul-

son, article by, p. 187.
Gilbertson, R. L., and J. P. Lindsey, article by, p. 42.
Growth of *Dipodomys ordii* (Rodentia: Heteromyidae), p. 215.
Halford, Douglas K., and Jere B. Millard, article by, p. 64.
Harmon, W., D. Wilken, C. Feddema, and H. Harrington, article by, p. 208.
Harper, K. T., Bruce A. Buchanan, and Neil C. Frischknecht, article by, p. 90.
Harrington, H., D. Wilken, W. Harmon, and C. Feddema, article by, p. 208.
Hawksworth, Frank G., and Robert L. Mathiasen, article by, p. 89.
Heckmann, Richard A., and James R. Palmieri, article by, p. 473.
Hedysarum occidentale var. **canone**, p. 314.
Hickman, Terry J., and Donald A. Duff, article by, p. 193.
Hosts of juniper mistletoe at Walnut Canyon National Monument, Arizona, p. 89.
Jenkins, M. Alan, James A. Mosher, Clayton M. White, and Joseph R. Murphy, article by, p. 438.
Johnson, Mark K., and James G. MacCracken, article by, p. 222.
Jorgensen, Clive D., H. Duane Smith, and Gary H. Richens, article by, p. 215.
Kaiparowits flora, p. 125.
Kay, P. A., and C. G. Oviatt, article by, p. 49.
Kennedy, Joseph L., and Paul A. Kucera, article by, p. 181.
Kucera, Paul A., and Joseph L. Kennedy, article by, p. 181.
Kucera, Paul A., article by, p. 203.
Lederer, Roger J., article by, p. 85.
Leptosporomyces **juniperinus**, p. 45.
Lichanura trivirgata **bostici**, p. 411.
Lindsey, J. P., and R. L. Gilbertson, article by, p. 42.
Llewellyn, Jeffrey B., article by, p. 51.
Lymantor **alaskanus**, p. 399.
MacCracken, James G., and Mark K. Johnson, article by, p. 222.
Mathiasen, Robert L., and Frank G. Hawksworth, article by, p. 89.
Maughan, O. Eugene, article by, p. 115.
Meringis **disparalis**, p. 447.
Meringis **facilis**, p. 451.
Millard, Jere B., and Douglas K. Halford, article by, p. 64.
Minshall, G. Wayne, and Robert L. Newell, article by, p. 55.
Morphometry of sculpins (*Cottus*) in the Clearwater drainage, Idaho, p. 115.
Mosher, James A., Clayton M. White, Joseph R. Murphy, and M. Alan Jenkins, article by, p. 438.
Mountain ants of Nevada, p. 379.
Mullen, David A., and Robert C. Stebbins, article by, p. 429.
Murdock, Joseph R., Stanley L. Welsh, and N. Duane Atwood, article by, p. 125.
Murphy, Joseph R., James A. Mosher, Clayton M. White, and M. Alan Jenkins, article by, p. 438.
Nebeker, G., J. D. Brotherson, M. Skougard, and J. Fairchild, article by, p. 19.
Neoperla **carlsoni**, p. 97.
Neoperla **catharae**, p. 98.
Neoperla **choctaw**, p. 99.
Neoperla **freytagi**, p. 101.
Neoperla **gaufini**, p. 101.
Neoperla **stewarti**, p. 104.
Newell, Robert L., and G. Wayne Minshall, article by, p. 55.
New range and a new subspecies for the snake *Eridiphas sleveni*, p. 406.
New species of nearctic *Neoperla* (Plecoptera: Perlidae), with notes on the genus, p. 97.
New synonymy, new species, and taxonomic notes of North American *Pityophthorus* (Coleoptera: Scolytidae), Part III, p. 71.
New synonymy and new species of American bark beetles (Coleoptera: Scolytidae), Part VII, p. 397.
Observations on the prey and nests of seven species of *Cerceris* (Hymenoptera: Sphecidae), p. 59.
Ottley, John R., article by, p. 411.
Ottley, John R., and Wilmer W. Tanner, article by, p. 406.
Oviatt, C. G., and P. A. Kay, article by, p. 49.
Oxytropis oreophila var. **juniperina**, p. 339.
Palmieri, James R., and Richard A. Heckmann, article by, p. 473.
Paulson, L. J., R. P. Axler, and R. M. Gersberg, article by, p. 187.
Pinus longaeva in the Stansbury Mountains, Utah, p. 49.
Pityophthorus **carinatus**, p. 73.
Pityophthorus **cavatus**, p. 74.

Pityophthorus carinatus **monticolae**, p. 73.
Pityophthorus **delicatus**, p. 399.
Pityophthorus **euterpes**, p. 75.
Pityophthorus **hesperius**, p 76.
Pityophthorus **imperus**, p. 76.
Pityophthorus **indigus**, p. 398.
Pityophthorus **intentus**, p. 77.
Pityophthorus **laticeps**, p. 78.
Pityophthorus **malleatus**, p. 79.
Pityophthorus **mesembria**, p. 80.
Pityophthorus **montezumae**, p. 81.
Pityophthorus **rubidus**, p. 400.
Pityophthorus **scalptus**, p. 82.
Pityophthorus **trepidus**, p. 83.
Pityophthorus **vesculus**, p. 401.
Pityophthorus **vespertinus**, p.83
Plants of Navajo National Monument, p. 19.
Primary productivity in meromictic Big Soda Lake, Nevada, p. 187.
Range extension of *Onychomys torridus longicaudus* (Rodentia: Cricetidae) in northwestern Nevada, p. 180.
Raptors of the Uinta National Forest, Utah, p. 438.
Rechel, E. A., and W. F. Campbell, article by, p. 456.
Reproductive biology of the tui chub, *Gila bicolor*, in Pyramid Lake, Nevada, p. 203.
Richins, Gary H., H. Duane Smith, and Clive D. Jorgensen, article by, p. 215.
Rubink, William L., and Howard E. Evans, article by, p. 59.
Rushforth, Samuel R., Larry L. St.Clair, and Lorin E. Squires, article by, p. 211.
Rushforth, Samuel R., Mark C. Whiting, and Jack D. Brotherson, article by, p. 31.
St.Clair, Larry L., Lorin E. Squires, and Samuel R. Rushforth, article by, p. 211.
Scolytodes **comitabilus**, p. 401.
Scolytodes **crinalis**, p. 402.
Scolytodes **crinitus**, p. 402.
Scolytodes **decorus**, p. 402.
Scolytodes **genialis**, p. 403.
Scolytodes **habilis**, p. 403.
Scolytodes **libidus**, p. 404.
Scolytodes **perpusillus**, p. 404.
Scolytodes **semipunctatus**, p. 405.
Shaw, R. Keith, article by, p. 123.
Similarity between pronghorn and mule deer fecal pellets, p. 222.
Skougard, M., J. D. Brotherson, G. Nebeker, and J. Fairchild, article by, p. 19.
Smith, H. Duane, Gary H. Richins, and Clive D. Jorgensen, article by, p. 215.
Squires, Lorin E., Larry L. St.Clair, and Samuel R. Rushforth, article by, p. 211.
Stark, Bill P., and Richard W. Baumann, article by, p. 97.
Stebbins, Robert C., and David A. Mullen, article by, p. 429.
Tanner, Wilmer W., and John R. Ottley, article by, p. 406.
The effects of radiation from uranium mill tailings on *Tradescantia*, p. 456.
The eye fluke disease (Diplostomatosis) in fishes from Utah, p. 473.
The reproductive ecology of the Tahoe sucker, *Catostomus tahoensis*, in Pyramid Lake, Nevada, p. 181.
Thurow, Thomas L., article by, p. 469.
Two new species of fleas of the genus *Meringis* (Siphonaptera: Hystrichopsyllidae), p. 447.
Utah flora: Fabaceae (Leguminosae), p. 225.
Vertebrate fauna of a radioactive leaching pond complex in southeastern Idaho, p. 64.
Vertical distribution of adult fish in Pyramid Lake, Nevada, p. 417.
Vigg, Steven, article by, p. 417.
Welsh, Stanley L., articles by, p. 1, 225.
Welsh, Stanley L., N. Duane Atwood, and Joseph R. Murdock, article by, p. 125.
Wheeler, George C., and Jeanette Wheeler, article by, p. 379.
Wheeler, Jeanette, and George C. Wheeler, article by, p. 379.
White, Clayton M., James A. Mosher, Joseph R. Murphy, and M. Alan Jenkins, article by, p. 438.
Whiting, Mark C., Jack D. Brotherson, and Samuel R. Rushforth, article by, p. 31.
Wilken, D., W. Harmon, C. Feddema, and H. Harrington, article by, p. 208.
Wood, Stephen L., article by, p. 397.
Xyleborus **devexulus**, p. 398.

The Great Basin Naturalist

VOLUME 38, 1978

EDITOR: STEPHEN L. WOOD

THE GREAT BASIN NATURALIST
BYU PROVO, UTAH
1939

PUBLISHED AT BRIGHAM YOUNG UNIVERSITY, BY
BRIGHAM YOUNG UNIVERSITY

NOTICE TO CONTRIBUTORS

Original manuscripts in English pertaining to the biological natural history of western North America and intended for publication in the *Great Basin Naturalist* should be directed to Brigham Young University, Stephen L. Wood, Editor, *Great Basin Naturalist*, Provo, Utah 84602. Those intended for the *Great Basin Naturalist Memoirs* should be similarly directed, but these manuscripts are not encumbered by a geographical restriction.

Manuscripts. Two copies of manuscripts are required. They should be typewritten, double spaced throughout on one side of the paper, with margins of at least one inch on all sides. Use a recent issue of either journal as a format, and the *Council of Biology Editors Style Manual, Third Edition* (AIBS 1972) in preparing the manuscript. An abstract, about 3 percent as long as the text, but not exceeding 200 words, written in accordance with Biological Abstracts guidelines, should precede the introductory paragraph of each article. Authors may recommend one or two reviewers for their article. All manuscripts receive a critical peer review by specialists in the subject area of the manuscript under consideration.

Manuscripts that are accepted and that are less than 100 printed pages in length will automatically be assigned to the *Great Basin Naturalist*. Those manuscripts larger than 100 printed pages in length will be considered for the *Memoirs* series.

Illustrations and Tables. All illustrations and tables should be made with a view toward having them appear within the limits of the printed page. Illustrations that form part of an article should accompany the manuscript. Illustrations should be prepared for reduction by the printer to either a single-column (2 5/8 inches) or double-column (5 1/2 inches) width, with the length not exceeding 7 1/2 inches.

Costs Borne by Contributor. Contributors to the *Great Basin Naturalist* should be prepared to donate from $10 to $30 per printed page toward publication of their article (in addition to reprint costs outlined in the schedule below). Authors publishing in the *Great Basin Naturalist Memoirs* may be expected to contribute $35 per printed page in addition to the cost of printed copies they purchase. No printed copies are furnished free of charge. A price list for reprints and an order form are sent with the galley proof to contributors.

Reprint Schedule of the *Great Basin Naturalist*

	2 pp.	4 pp.	6 pp.	8 pp.	10 pp.	12 pp.	Each
100 copies	$20	$24	$28	$32	$36	$40	additional
200 copies	28	32	36	40	44	48	2 pp.
300 copies	36	40	44	48	52	56	$4

Great Basin Naturalist Memoirs

No. 1 The birds of Utah. By C. L. Hayward, C. Cottam, A. M. Woodbury, H. H. Frost. $10.

No. 2 Intermountain biogeography: A symposium. By K. T. Harper, J. L. Reveal, et al. $15.

TABLE OF CONTENTS

Effect of irrigation on survival of third-stage *Haemonchus contortus* larvae (Nematoda: Trichostrongylidae). Graham R. Bullick and Ferron L. Andersen 369

Mountain ants of Nevada. George C. Wheeler and Jeanette Wheeler 379

New synonymy and new species of American bark beetles (Coleoptera: Scolytidae), Part VII. Stephen L. Wood 397

New range and a new subspecies for the snake *Eridiphas slevini*. John R. Ottley and Wilmer W. Tanner 406

A new subspecies of the snake *Lichanura trivirgata* from Cedros Island, Mexico. John R. Ottley 411

Vertical distribution of adult fish in Pyramid Lake, Nevada. Steven Vigg 417

An addition to the amphibian fauna of California. David A. Mullen and Robert C. Stebbins 429

Raptors of the Uinta National Forest, Utah. James A. Mosher, Clayton M. White, Joseph R. Murphy, and M. Alan Jenkins 438

Two new species of fleas of the genus *Meringis* (Siphonaptera: Hystrichopsyllidae). Richard B. Eads 447

The effects of radiation from uranium mill tailings on *Tradescantia*. E. A. Rechel and W. F. Campbell 456

Contributions to the biology of the woundfin, *Plagopterus argentissimus* (Pisces: Cyprinidae), an endangered species 463

An ecological and taxonomic investigation of *Peromyscus maniculatus serratus* in Idaho. Thomas L. Thurow 469

The eye fluke disease (Diplostomatosis) in fishes from Utah. Richard A. Heckmann and James R. Palmieri 473

Bite of wolf spider. Dorald M. Allred 478

Acme
Bookbinding Co., Inc.
100 Cambridge St.
Charlestown, MA 02129

3 2044 072 231 020